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IN SCIENCE TEACHING NUMBER

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CONTENTS

GEORGE WEBSTER HAUPT

It is with deep regret and a sense of personal and professional loss that we report the death of Professor George Webster Haupt. His death on June 9, 1955 was caused by leukemia. Professor Haupt was born June 15, 1900, in Sunbury, Pennsylvania. He married Grace Good of Watsontown, Pennsylvania, in 1925. Survivors include a daughter Mrs. Barbara W. Hasbrouck and a son Hans S. Haupt.

Dr. Haupt received a B.S. degree from Bucknell University in 1922 and M.A. (1929) and Ph.D. degrees (1935) from Columbia University. Dr. Haupt taught science in high schools in Pennsylvania and New Jersey 1922–29. He taught science in the Horace Mann School, Teachers College, Columbia University, 1929–32. During this same period he taught science classes in Teachers College, Columbia University. During the period 1932–36 he taught science at the Massachusetts State Teachers College in Westfield, Massachusetts. Since 1936 and at the time of his death he was professor of science education at the New Jersey State Teachers College, Glassboro, New Jersey. Summer session teaching included Columbia University (1933), Bucknell University (1935), Syracuse University (1936), Northwestern University (1937, 1938, 1939), Johns Hopkins University (1940, 1941, 1942), New York State Teachers College at Buffalo (1943, 1944), National Life Camps, Sussex, New Jersey (1948), Duke University (1949, 1950, 1951), and University of Vermont (1952). During World War I Dr. Haupt served some six months in the U. S. Army.

Membership in organizations included the *National Association for Research in Science Teaching, National Council for Elementary Science, National Society for the Study of Education, American Association for the Advancement of Science, Kappa Delta Pi, Phi Kappa Psi, American Legion, New Jersey Science Teachers Association,* and *Association for Childhood Education.*

Honors included: President of National Council for Elementary Science (1948), Fellow of the AAAS, Coordinator South Jersey Science Fairs (1949–53), Chairman of Teacher Education Committee of Truman Conference on Safety Education, NARST Committee on Atomic Energy, Committee on Science Consumer of the N. E. A. In addition to his well known and widely quoted doctoral dissertation *An Experimental Application of a Philosophy of Science Teaching,* Dr. Haupt was co-author of *Curriculum Guide to Fire Safety* Bulletin 1946, No. 8, U. S. Office of Education and *Aviation Education for Teachers* published by Division of Higher Education of the state of New Jersey. Dr. Haupt greatly enriched the professional literature of science education by contributing some forty articles to various magazines such as *Science Education* (10), *School Science and Mathematics* (4), *The Monthly Evening Sky Map* (2), *Main Currents in Modern Thought, The Science Teacher, The Science Classroom* (4), *The Instructor, New Jersey Educational Review* (2), and *Journal of N. E. A.* Professor Haupt served as Chairman of the Elementary Science Level Committee of the Second Annual Review of Research in Science Teaching published in the December, 1954, issue of *Science Education.* Professor Haupt is the third noted loss in the field of elementary science education in less than a year, the others being Professors Joe Young West and W. C. Croxton. Each of these well known leaders made outstanding contributions to the field of elementary science education.

SCIENCE EDUCATION

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THIRD ANNUAL REVIEW OF RESEARCH IN SCIENCE TEACHING

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The preparation of this report has involved the active participation of a large number of science educators. The report has the merit which attaches to a product which results from cooperative activity. It represents a composite evaluation of the research currently being produced in the general field of science education. However, to some extent it no doubt reflects the weaknesses and inconsistencies that a cooperative venture so typically displays in that the standards of evaluation were not always uniformly applied. Although all committee members were instructed to employ the NARST definition of research * in considering studies, there remained considerable latitude for exercise of individual judgment when specific studies were appraised.

The studies selected for review include published research articles and unpublished research investigations appearing between July, 1953 and July, 1954. Some earlier unpublished studies not reviewed in the First † (two parts) or Second ‡ Reviews of Research are also included. In most cases, abstracts of unpublished studies were made available to the NARST Reviewing Committee by the United States Office of Education.

The Committee clearly recognizes the limitations of this summary because of the necessity of preparing a review based on the frequently inadequate reports available to it. It would be highly desirable if a

* "What Constitutes a Research Investigation in Science Education," *Science Education*, 37 (February, 1953) 53–54.

† Mallinson, George Greisen. "Some Implications and Practical Applications of Recent Research in the Teaching of Science at the Secondary-School Level." *Science Education*, 38 (February, 1954) 58–81.

† Buck, Jacqueline V., and Mallinson, George Greisen. "Some Implications of Recent Research in the Teaching of Science at the Elementary-School Level." *Science Education*, 38 (February, 1954) 81–101.

†† Anderson, Kenneth E., Smith, Herbert A., Washton, Nathan S., and Haupt, George W. "Second Annual Review of Research in Science Education." *Science Education*, 38 (December 1954) 333–365.

small fund could be made available to the Committee so that reviews of all unpublished studies could be made from the original documents. In some cases the availability of supplemental materials related to published studies would aid materially in preparing a more adequate review. Nevertheless, the Committee is pleased to submit this Third Review in the hope that it will be useful to students and faculty members actively at work in some phase of science education.

REVIEW OF RECENT RESEARCH IN THE TEACHING OF SCIENCE AT THE ELEMENTARY SCHOOL LEVEL I

JACQUELINE BUCK MALLINSON, *Chairman,* DONALD BOYER, *Vice-Chairman,* MURIEL BEUSCHLEIN, N. ELDRED BINGHAM, PAUL E. BLACKWOOD, CLYDE M. BROWN, STANLEY B. BROWN, LOUIS T. COX, JULIAN GREENLEE, CLARK HUBLER, ROSE LAMMEL, GEORGE G. MALLINSON, CLIFFORD G. MCCOLLUM, BERNARD E. MICHALS, JOHN G. NAVARRA, LOUISE A. NEAL, GEORGE L. TERWILLIGER, HANOR A. WEBB, G. MARIAN YOUNG, AND GEORGE P. ZIMMER

RESEARCH STUDIES RELATED TO THE CURRICULUM

What Is Currently Being Taught in Elementary-School Science?

IN nearly all areas of education, studies appear frequently in which the survey technique is used for studying curriculum content and material. In the field of elementary science several such studies have appeared during the past year.

Galeno [6] conducted such a study of course content of elementary-school science in schools in the San Francisco area. This study was designed to: (1) discover existing practices, (2) develop a new type of elementary science course, and (3) develop a "science kit" and an audio-visual guide to implement the new course.

For the first phase of the study, class visitations and personal interviews were held with 1,246 elementary teachers in 81 schools. A workshop was used for accomplishing the second and third phases. The study produced teaching guides for grades I through VI. Science kits and audio-visual lists were developed to accompany the units in the guides.

Dubins [5] undertook a similar study designed chiefly: (1) to analyze the content of several elementary science courses of study and (2) to determine the methods employed to improve elementary science instruction. Courses of study published from 1940–1952 were assembled and the contents analyzed. The contents were then synthesized into a "subject-matter content guide." He found that a great variety of topics, a total of 476 major ones, appeared in the various guides. Of these, less than 4 per cent recurred in over one-half of the 163 courses of study. He concluded that there were some possible implications for grade placement of several of the major topics.

In the next phase of the study, inquiry forms concerning efforts to improve instruction were sent to: (1) 219 teachers in a random sampling of towns and cities throughout the country, (2) each state department of education, (3) 67 science educators and to members of a direct request sample. From an analysis of the inquiry forms, he concluded that the larger cities are more likely to provide aids to teachers such as courses of study, consultant services, conferences and workshops. In addition, most states have colleges that offer workshops for elementary teachers. However, fewer than ten per cent of the

states have agencies which publish pamphlets in science periodically for the elementary teacher.

What Constitutes a Desirable Elementary Science Curriculum?

Surveys of curricula do little more than identify practices, among which are found both desirable and undesirable elements. The next step obviously is to use the evidence for improvement. In an effort to determine how current curriculum practices compare with the "ideal," Marsh [10] compared the content of nineteen courses of study identified by the U. S. Office of Education, and placed in use since 1945, with the contents desired by thirty-five elementary teachers considered "expert" in science. These "expert" science teachers were selected by elementary school supervisors, who had been recommended by Blough and Blackwood of the U. S. Office of Education. A check-list prepared by the investigator served as an instrument for obtaining information relative to the content in science desired by the elementary teachers.

The study outlined several findings relative to the preferred format and organization of courses of study. In addition, it was found that the teachers regarded electricity, living things, weather and climate, astronomy, simple machines, plants, animals, magnetism, conservation, and health as the ten most essential units of the elementary science curriculum.

The investigator concluded that courses of study placed in use since 1945 agree rather well with the preferences of expert teachers, especially with respect to subject matter. The greatest disagreement was in the general pattern and format of the courses of study.

The factor of interest is one criterion that determines the desirability and value of a curriculum. In an effort to satisfy this criterion, Jackson [7] attempted to identify some of the science interests of elementary children and to devise activities to satisfy these interests. Consequently she observed a group of fifth grade children, who had had no prior systematic science instruction. Children were observed on the playground, in the classroom, and in many out-of-school activities in order to identify their science interests.

After the children's science interests were thus identified, an attempt was made to plan experiences and instructional materials based primarily on their predominant science interests. For these students it was found that the topic of "rocks" was of greatest interest, followed by turtles, magnetism, electricity, sound and hearing, air, and the earth's surface.

A study concerned with desirable teaching methods was conducted by Carlock [3]. Using the subject of air pollution, he sought to develop a method for planning experiments that was consistent with desirable methodology and to formulate a plan of writing experimental procedures of greatest value for classroom teachers. The specific topics selected for teaching the subject were those which could be clarified by the use of an experiment. Experimental procedures were then devised and tested. The results were "evaluated according to the characteristics proposed and acceptable procedures [were] formulated for use by classroom teachers."

The specific experiments included: (1) a model Cottrell precipitator, (2) the effect on plant growth of reduced light intensity, and (3) cloud and fog formation as related to air pollution.

A method for planning science activities and for use of resource information for the classroom teacher relating to the specific topic of air pollution was listed as the primary result of the study.

At What Specific Grade Levels Should Certain Science Topics Be Presented?

Recently much research has been devoted to assigning various topics of science to specific age or grade levels. The aims of these studies are to determine the levels at which optimal learning of the topics may be accomplished.

Among such studies is one by Oxendine [13]. He selected the principle, "sound is produced by vibrating material" and used a classroom demonstration technique with a test group composed of a fourth grade class and a sixth grade class to "discover at which grade level in relation to mental age the teacher may expect to get maximum learning." He administered a pre-test based on the selected science principle to the entire group. Then, by random selection he divided each of the two classes in half. One-half of the sixth grade class was combined with one half of the fourth grade class to form the experimental group. The remaining halves were combined to form the control group.

The experimental group witnessed a lecture-demonstration on the principle while the control group had "a silent reading period." Both groups then took a post-test that had a coefficient of reliability of .77, and which was identical with the pre-test except that the "correct responses had been scrambled." To establish mental age, all students were given the Otis Quick-Scoring Test. After a period of three to four weeks the post-test was again administered to measure retention.

No significant difference with respect to achievement on the post-test was found between the experimental group and the control group. However, the investigator concluded that the fourth-grade pupils were not ready for the principle since only twenty-seven per cent of them could master the test. He concluded that the sixth graders were ready for it since after seeing the demonstration fifty-seven per cent of them mastered the test.

Between the post-test and re-test, there was a significant increase in knowledge of the principle. This may have been due to factors such as pooling of experiences, practice effect of the test, or a gain in information regarding the principle. "Therefore the investigator . . . [believed] that the retention of knowledge is good when the lecture-demonstration method is used in teaching science by principles."

A similar study was conducted by McCarthy [8]. He performed three experiments using a lever, a pulley and an inclined plane. Following a demonstration, children were permitted to repeat the experiment. It was found that below a chronological age of five years, eleven months, none of the children could be expected to perform the experiments. With children of a chronological age of six years, ten months, fifty per cent achievement was attained, that is, one-half could do the experiments. At a chronological age of eight years or above 100 per cent performance could be expected.

Another study by McCollum [9] concerns the relationship between subject matter and maturity. "This study is essentially designed to evaluate the success of an individual interview technique in securing evidences of changing maturity as related to science subject matter."

Two hundred thirty-four elementary children in grades one through six in Cooper County, Missouri were presented with various science topics in the form of demonstrations, pictures and displays. They were asked to give scientific explanations of them. Their verbal responses and performances to fifteen general science topics were then recorded.

Frequency graphs were then made of the like responses. It was found that the graphs could be categorized into four general types—graphs in which the frequency of like responses: (1) increased from grade one through six, (2) decreased from grade one through six, (3) was highest in the third and fourth grades, and (4) showed irregularity.

The investigator believed that the patterns of changing frequencies of responses were indicative of a developmental progress. He concluded that: (1) certain explanations of scientific phenomena given verbally, or certain performances carried out, tend to be the *correct* ones, since their frequency increases with the students' maturity; and (2) certain explanations of scientific phenomena given verbally, and certain per-

formances carried out, tend to be the *incorrect* ones, since their frequency decreases with the students' maturity.

The investigator postulated that a curriculum based on this type of study could result in a more appropriate grading of science topics suitable for the first six grades of the elementary school.

What Methods Have Been Devised for Vitalizing the Curriculum in Elementary Science?

In addition to studies concerned with course content, there has been some research concerned with methods and materials for enriching and vitalizing the science curriculum. One such study by Tappe [19] presents the "workings, ideals and goals of junior museums," with specific reference to Bridgeport, Connecticut's Wonder Workshop Junior Museum. The paper describes the history of children's museums and outlines the formation and activities of "Wonder Workshop" as well as its problems and plans for the future.

Barnett [1] conducted a study of the Florida Marine environment as a resource unit for vitalizing the curriculum in elementary science. She studied materials related to the beach environment and determined that "an extensive knowledge of biology and ecology is not necessary for profitable utilization of marine materials in the elementary science program." In addition, she concluded that such a study can "contribute to many aspects of education" and can "develop broader understandings and concepts of the sea and its inhabitants."

Another study concerned with curriculum enrichment was done by Pyle [16]. She studied the materials published by the U. S. Government and the states on fish and fisheries management, and discussed their suitability for use by persons without technical training and for children's camping programs.

A questionnaire survey of conservation departments was made in order to collect their materials on this topic. She then analyzed them with respect to the uses described. She concluded that "many fine fisheries bulletins are published, but not nearly enough teaching deals with fish, their conservation and natural history." The author stated further that "the bulletins should be used for reference, but many field trips and talks by people with technical knowledge who know how to talk interestingly to children and lay adults offer more valuable experience."

RESEARCH STUDIES CONCERNED WITH LEARNING

What Are Some of the Factors Involved in the Learning Process?

In science, as in any area of education, it is essential to study the methods by which optimal learning is accomplished. In an attempt to determine how children learn, Navarra [12] conducted a study in which he made a thorough observation of one young child and in which he hypothesized that "an extended analysis of some concerns of children may provide specific handles with which the task [of teaching elementary science] can be approached."

From his observations he concluded that the concept of science and the concept of the developmental concerns of children are very similar in motivation and origin. Hence it is imperative for the classroom teacher to fuse these two compatible processes.

He further postulates that children's inquisitiveness should not be inhibited and that elementary science should provide more experiences to help children resolve their concerns. He suggests that "one of the underlying purposes in elementary science is to encourage, stimulate, and maintain the inquisitiveness of children and to facilitate in every way possible the ability of the child to cope with *his concerns* as they arise in the course of his development."

Another approach to the problem of learning was made by Serra [18], who conducted a study concerned with the com-

prehension of verbal abstractions by fourth-grade children. She tried to determine the relationship that exists between: (1) comprehension of verbal abstractions and background of information, (2) verbal abstractions and intelligence, and (3) classifying ideas and indexing ability. Two main procedures were followed. These involved the construction of tests and their administration to 100 fourth grade children. The verbal abstractions used in the study were obtained by analyzing three sets of primary basic readers and a set of science books. The analysis resulted in a list of 246 verbal abstractions.

The verbal intelligence of the children in the study was determined by administering the 1937 form of the Stanford-Binet Test. The background information, ability to classify ideas and ability to index ideas were measured by three tests constructed and standardized by the investigator.

The study revealed high positive relationships between: (1) the comprehension of verbal abstractions and background of information; (2) the ability to classify ideas and background; and (3) ability to index ideas and background. Very high positive relationships were found between (1) comprehension of verbal abstractions and intelligence; (2) ability to classify and intelligence; (3) ability to index ideas and intelligence; and (4) ability to index ideas and ability to classify.

Brown [2] studied the science information and attitudes possessed by California elementary-school children. He selected a group of fifth-grade and a group of eighth-grade students, taking into account the factors of sex and geographical location. Science information and attitude tests were prepared and administered to 2,901 pupils in 41 schools representing 14 urban, 9 suburban, and 18 rural communities. The tests covered such areas as biological science, physical science, conservation and consumer education. The coefficient of reliability of the information test was found to be .90, while that of the attitudes test was .73.

He found that urban and suburban children possessed somewhat similar attitudes and information. Boys in both grade levels obtained somewhat higher scores on the information test than did girls, although they were about equal on the attitudes test. Rural children were found to have more favorable attitudes, as measured by the test, and to possess slightly more science information than urban children. When the two grade levels were compared, it was found that the older children gained more in information than they did in attitudes. It was suggested therefore that the development of desirable attitudes was having only limited success.

RESEARCH STUDIES RELATED TO SCIENCE FACILITIES

What Types of Facilities and Equipment are Recommended for an Adequate Elementary Science Program?

While a special science room and a large supply of science equipment are not essential for an elementary-school science program, it is generally agreed that such factors aid greatly in its improvement. Hence, some research has been conducted in an attempt to identify the facilities which are most desirable.

Perhach [14] conducted a study in which he attempted to develop a list of science equipment and materials of value for administrators, supervisors, and teachers in developing and maintaining a basic elementary science course. He prepared lists of science equipment based on the needs outlined in eight widely used science textbook series published from 1940–1952 and in the accompanying teachers' manual. A "composite preferred list," based on the listing of the equipment in four or more of the series, and its use on two levels, namely grades 1–6, and grades 7 and 8, was then developed.

These findings were compared with similar studies, and recommendations for their

use were given. It was suggested that the resulting list could be used as a checklist for school systems planning to order science equipment.

A more extensive study relating to science facilities was conducted by Sachs [17]. The major purpose of his study was to appraise the science facilities in the elementary and junior high schools in New York City. He first conducted a pilot study in a specific geographical area in Manhattan. The objectives of the pilot study were to establish: (1) the kinds of data pertinent to the investigation, (2) standards for expressing science education requirements, (3) techniques for inspection of science facilities, (4) criteria for modernization of sub-standard facilities, and (5) future additional needs in the pilot area.

An estimate was made of the future enrollments in the area by appraising census trends, type of community, history of enrollments, and other factors. The existing science facilities were then inspected and appraised on the basis of their present adequacy and suitability, and their capacity to handle the estimated future enrollments. A check-list type of rating scale was used in appraising the existing facilities and in making recommendations for modernization and replacement. Recommendations were also made for the installation of suitable and adequate facilities in proposed new schools.

It was found that the majority of the schools in the pilot area were inadequately equipped for a program of science. Recommendations were made for a policy of priority with reference to needed improvements. It was further suggested that this type of study be applied to other geographic areas.

RESEARCH STUDIES RELATED TO THE ROLE OF THE TEACHER IN ELEMENTARY SCIENCE

Most science educators would agree that although curricula, textbooks, and facilities are all important factors in the teaching of elementary science, the teacher is still the most important factor in determining its success. Hence, many investigations have been conducted that relate to the training of teachers, and the influence of the teacher in the classroom.

One of the factors that greatly influences the ability of the teacher is, of course, her pre-service training. Recently there have been many studies devoted to teacher-training. This past year a report of another such investigation appeared. It is one by Mott [11] designed to determine the "felt needs" of nursery-primary teachers, not only in their work, but in their personal lives as well; and to determine the requirements for certification of these teachers.

A representative sampling of 420 Southern Illinois teachers was selected, and a study made of all their activities for an entire week. This was accomplished by having the subjects prepare records at half-hour intervals. From these the "felt needs" were determined. Information was also obtained regarding marital status, dependents, and residence.

The certification requirements of the various states were then tabulated and a curriculum containing those items which most states required was outlined. The "felt needs," in terms of content, were likewise tabulated for contrast. The summary was then checked by eight primary teachers. It was concluded that, "if such courses as chemistry, physics and mathematics will be reconstructed to meet the felt needs of the primary teacher, it is all right to include them, but as they now stand in many colleges and universities they should be omitted and new courses constructed which will be of value to the housewife-teacher."

Another study relating to the role of the teacher was conducted by Piltz [15]. He attempted to "determine what factors, in the opinion of the classroom teachers, handicap the teaching of science in elementary school; to find what, if any, relationship exists between the aspirations of teachers and the difficulties they think they face."

The study was carried out by: (1) a survey questionnaire of a ten per cent stratified random sample of all Florida teachers, (2) an interview of a limited sample of these teachers, and (3) observations and discussions in certain teaching situations. The resulting information concerning difficulties was grouped in the categories used in the questionnaire, namely: (1) methods and techniques; (2) content, subject matter, area of experience; (3) resources, materials, equipment, consultants; (4) field trips, excursions, walks; (5) physical facilities; (6) library facilities; (7) personal qualities; (8) administration and supervision; and (9) curriculum.

It was found that there is general agreement as to what teachers consider to be the factors limiting science teaching in the elementary school. The majority considered the category of "physical facilities" to be the greatest obstacle. Overcrowding of pupils and the use of obsolete desks discourage many teachers from engaging in any activities. "Materials, equipment and resources" was also listed as a major difficulty. More specifically, the lack of funds to buy new equipment and the lack of ability to improvise materials were of major concern.

The majority of the teachers polled expressed weakness in methodology of science teaching and many lacked confidence in their ability to handle the science subject matter. Almost all principals in the schools surveyed were of the opinion that lack of training, interest, time, and materials limited science teaching. In general, it was concluded that "in the teaching of science in the elementary school, there appears to be a wide gap between theory and practice."

Conrad [4] also conducted a study involving the role of the elementary-science teacher. In this study the science practices used by selected elementary teachers were reviewed. An attempt was made to determine who is responsible for teaching elementary science, where and when it is taught, what equipment is available, and what improvements in elementary science instruction are needed.

Data for the study were obtained from seven science supervisors and thirty-five elementary science teachers in Cleveland, Louisville, Ft. Wayne, Richmond, Indiana, and New Castle, Indiana. The teachers were interviewed and observed in their classrooms, and each submitted information relative to their science practices on a questionnaire prepared by the investigator.

It was found that: (1) homeroom teachers were responsible for nearly all of the science taught in kindergarten through the sixth grade; (2) a definite science period each week was characteristic of more than one-half of the teachers interviewed; (3) movable tables and chairs in the classrooms made group work much easier; (4) more than one-half of the science equipment was stored in storage rooms; (5) science books and magazines were used extensively in all schools observed; (6) five science units ranked in order of importance to the thirty-five teachers were: plants, weather, health and safety, animals and air; (7) the farm, a walk, the dairy, parks, and the airport were considered the most important places for field trips; and (8) more time to plan, more time to teach science, more trained teachers in elementary science, and more integration of science work were major suggestions for needed science improvement.

SUMMARY

Since this review is a summary of recent research in the field of elementary science, no attempt will be made to summarize the findings further. Rather, a few general statements will be made concerning them.

Perhaps one of the most outstanding features of this review is the large number of studies it contains. In the First Annual Review of Research,[1] which covered the years 1929–1952, 82 studies were summa-

[1] *Op. cit.*

rized. An average of less than four studies per year were considered appropriate for inclusion in the Review. In the Second Annual Review,[2] for the year 1952–53, 17 studies were reviewed. However, in this Third Annual Review, for the year 1953–54, 19 studies are included. Hence, it would appear that elementary-school science has "come into its own" as a subject of research work.

A survey of this research indicates that the nature, importance, and status of elementary science is now well established. Henceforth, it might be well for research workers to focus their studies on the methods that might be employed to improve instruction in elementary science. The problems of how to teach critical thinking and improve scientific attitudes are still in need of much study. This is also true for evaluation.

It might be well for future research workers interested in elementary science to survey the studies done in the past so that needless repetition is avoided, and efforts may be directed toward some of the major unsolved problems.

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[2] *Op. cit.*

REVIEW OF RECENT RESEARCH IN THE TEACHING OF SCIENCE AT THE SECONDARY SCHOOL LEVEL II

Report of the Secondary School Sub-Committee

Clarence H. Boeck, *Chairman*, William Reiner, *Vice-chairman*, Arthur J. Baker, Sam Blanc, George T. Davis, Warren M. Davis, Paul DeH. Hurd, Margaret S. McKibben, Archie MacLean, Greta Oppe, James A. Rutledge, Harold S. Spielman, Ralph K. Watkins

Studies Related to Trends in Science Education

The trends in science education as seen by Brown [6] were compiled through a study of current issues of leading science education periodicals and textbooks, various yearbooks in the field, investigations of committees studying the problems of modern science education, and an analysis of the opinion of experts. He listed 21 trends in curriculum and in course of study revision and 22 in methodology. Although there appears to be overlapping in the lists of findings, this is not surprising, neither is it disconcerting, for there can be no sharp line of demarcation drawn between methods and content in science teaching.

Hurd [12] examined 1,373 articles of opinion (as opposed to research) from *School Science and Mathematics* for the period 1901–1951 and *Science Education* for the period 1931–1951. He then classified 3,133 opinions by topical area and by frequency of occurrence for each decade thus providing for statements of present thinking and changes in expressed opinions. The topical areas included: psychology of learning, objectives of teaching, criteria for selection of content, organization of content, classroom procedures, laboratory procedures, testing and evaluation, new courses or topics, and teacher education and qualifications. Some of the important expressed points of view in the writings from the past half century included: (1) some of the difficulties encountered in science teaching may be partially due to a failure to apply the results of pertinent psychology of learning; (2) in the last decade, an interpretation of the objectives of science courses in terms of general education has been the leading subject for teachers writing on science education; (3) the use of college entrance requirements and single textbooks as bases for the selection of course content is consistently rejected, and in their place are the social significance of science and its functionality in the lives of individuals and to society; (4) current problems of greatest social significance which also provide for an integration of science and non-science subject matter should be the bases of course organization; (5) there is expressed disappointment concerning available research on the effectiveness of the different teaching methods commonly used in classrooms; (6) better learning could be achieved if science laboratories were better equipped, for there is now greater concern over the *how* of laboratory work than the *why;* (7) all teaching objectives should be tested and provision should be made to test for students' application of knowledge to life situations; and (8) teachers express a desire for the type of training recommended in the yearbooks on science teaching to enable them to put into practice many modern concepts of science teaching.

Studies Concerning Science Courses and Curricula

From an analysis of published materials, periodicals and texts, Caldwell [7] sought to determine those principles of earth science which might be used in the program of general education for secondary schools and, in addition, to determine the relative

importance of these principles. A jury of 5 science educators who were leaders in the field of science teaching rated each of the 332 principles obtained. On the bases of their independent ratings, 296 were judged to be of sufficient importance for inclusion in courses for general education. A break down of those to be included showed 123 from geology, 60 from physical geography including weather and climate, 60 from astronomy, and 53 from the scientific aspects of conservation.

Schroeter [24] also working on curriculum development in the earth sciences sought to determine: (1) the concepts and topics sufficiently important to be included in science courses, (2) what materials were available to high school teachers for development of these topics and concepts, and finally, (3) what a program of earth science teaching for secondary schools should include.

Ten general topics and 57 concepts of importance were selected from 30 sources by 127 science teachers, administrators and scientists from the U.S.A. and Canada. Courses of study and textbooks from 164 representative California secondary schools were examined for the presence of these topics and concepts. Three scientists determined 908 problems of importance about which a course of study was built. The investigator recommended that earth science courses be concerned with the development of at least these selected topics and concepts and be focused on an understanding of the unity of the earth and its relation to man. The author suggested that studies are needed to determine the grade level boundaries within which study of a particular topic or concept seems advisable and to determine the sequence for introducing the concepts and topics to the learner.

Glidden [10] in his study of soil and water conservation teaching in secondary schools sought answers to three problems: (1) What principles should be developed? (2) How well are they being learned? (3) Do modifications in the curriculum for these areas of learning seem desirable?

A list of 66 basic principles was selected and approved. Specialists and conservationists supplied lists of printed materials from which the original list of principles was selected. A second group of specialists checked these principles for the completeness of the list and the clarity of the statements. Finally, the revised list was evaluated by two groups of specialists, science educators and secondary curriculum educators, for inclusion in a school curriculum. Undesirable items were eliminated on the basis of statistical analyses.

The second problem was answered through the administration of a test to seniors in selected secondary schools. The test was given a trial with classes at Colorado State College of Education. It was then revised and readministered to first quarter freshmen at the college. A valid and reliable test resulted. The results of testing at the secondary school level showed significant differences in achievement between pupils enrolled at different schools. Differences, not conclusive, were in favor of pupils whose courses included biology, chemistry, physics, social science rather than general science, physiology, consumer science, geography and senior science. Neither the size of population center nor geographic location seemed to affect knowledge in the area of investigation.

The range of test scores was considered low and indicated that learnings, planned or vicarious, were insufficient to meet desirable standards. Curriculum changes were indicated to overcome the deficiencies.

The status of science courses in the curriculum of a secondary school depends not only upon the thinking of the science educator but upon the administrators, local and statewide, with whom he works. In some instances the status is determined by legal action; in others, it is due to the kind of job the science teachers are doing in selling their product to the administrators. Some of the determiners of status were investigated in the following studies.

Kaikow [13] determined the legal and administrative status of Conservation Edu-

cation in the United States. His study was concerned with: (1) the extent to which conservation education has been given official as well as unofficial recognition and (2) the type of material taught as conservation. His primary techniques of investigation included the questionnaire, interviews and personal observations, examination of courses of study, reports in periodicals and the publications of interested organizations. He found that 11 states have some mandatory legislation concerning conservation education although schools do not all adhere strictly to the laws. In addition, 25 states and the District of Columbia have some sort of official policy and three are in the process of transition to a definite policy. In a few states, the burden of conservation education is carried by conservation authorities. "Total conservation" is taught in but relatively few states. In most instances emphasis is placed on renewable, organic resources while the exhaustible resources are largely ignored.

Kercheval [14] in his concern about why certain senior high schools in Iowa did not offer chemistry in their programs made inquiries of 850 school officials through a questionnaire. Three hundred ninety schools responded of which 251 had no chemistry. The reasons for not offering chemistry are given in their order of frequency: no community demand (55 per cent of the replies); too expensive; lack of room; no qualified teacher; of insufficient value; and no time available in the curriculum.

Sister M. Amadeus Ray [23] investigated the status of integrated physical science courses in senior high schools in the United States. She defined these courses as integrating: physics, chemistry, geology, meteorology, and astronomy and as planned especially for grades 11 and 12 and occasionally for grade 10. State Departments of Education of 24 states yielded the names of 100 secondary schools in cities of 5,000 or more population. Of 70 schools responding, 40 offered such a course. Her report provides course titles, time allotments, grade level assignments, laboratory period numbers and time allotments, textbooks used and topics covered. She concluded that the number of such offerings seemed to be increasing with more pupils enrolled in the courses. Usually, but not always, the non-college bound student is enrolled in these courses as a substitute for traditional upper-level science courses.

Studies Relating to Science Interests

Blanc [4] analyzed 10 randomly selected biology textbooks for their main topics, from which 92 were selected. Tenth and eleventh grade pupils in their second semester of biology then checked a questionnaire as to their interest (yes or no) in the topics selected. A random selection of equal numbers of boys and girls from each grade and at four achievement levels were used and results were interpreted on the basis of the differences in percentages between *yes* and *no* responses. He found there was no consistent relationship between topics emphasized by authors of textbooks and the expressed interests of students, although the higher achieving pupils were more inclined to agree with author's emphasis than the lower achievers. In most cases there was a high correlation among the four pupil groups with respect to interest or lack of interest in these topics.

High school pupils at Hillside School, Durham, North Carolina were the subjects of interest research conducted by Alston [3]. His work was concerned with four major problems: (1) to determine the science subject areas in which boys and girls express high and low interests; (2) to determine whether or not significant relationships existed among interests in the three science areas sampled by the interest index and whether or not science interests were related to interests in reading and manipulative activities; (3) to determine whether average marks in science were related to

science interests; and (4) to discover the extent to which opportunities were provided in school for pupils to explore their expressed science interests.

The *Interest Index* prepared by the Evaluation Staff of the Eight-Year Study was administered to 100 pupils in grades 9 to 12. Product moment correlations were calculated in an effort to uncover important relationships between the several categories of data on interests. Three achievement groups were established on the basis of the average mark in science and on the basis of expressed interests in science. Comparisons of these sub-groups were made. Finally, a check list of outstanding interests was compared with a list of science activities in the school.

The major findings of the study showed: (1) the strongest interests of boys were in physical science, biology, and manipulative activities in descending order; (2) the strongest interests of girls were biology and reading in that order; (3) the boys exhibited less variability in their dislikes in mathematics than girls, though the girls disliked a larger number of mathematics activities; (4) correlations between physical science and mathematics interests of boys were high (.94) and significant; (5) for girls a correlation of .77 between physical science and manipulative interests was obtained; (6) a correlation of .18 was found between mathematics and manipulative activities for girls; (7) girls exhibited the greater tendency toward verbalistic activities while boys exhibited the greater tendency toward manipulative activities; (8) correlations between biology and physical science were .70 for girls and .54 for boys; (9) there was little or no relationship between interests of students and their average achievement marks in science.

Mark [20] analyzed physics, chemistry, and 9th grade general science textbooks, the latter for earth science materials, to determine the most common topics. These topics were selected and ranked in importance by 10 "experienced and willing science instructors." An inventory of 50 earth science, 60 chemistry, and 100 physics topics (75 per cent of the topics from each area's highest ranking items) was prepared.

Four hundred high school pupils from 20 Ohio schools checked each topic for one of four levels of interest. The topics of highest ranking were then incorporated into units for teaching a high school general physical science course for pupils who were choosing non-science careers. The published study listed the highest and lowest 10 per cent of the topics as rated by the pupils on the basis of interest. The investigator concluded: (1) students expressed great interest in current science topics such as radioactivity, interplanetary travel, and atomic energy which in most cases are studied at the end of the school year if time permits; (2) many laws and basic principles were ranked low which does not necessarily indicate the elimination of such content from the curriculum but rather a more functional presentation of them; (3) functional topics such as home wiring, photography, and removal of stains ranked high; (4) subject matter which students understand better because of repetition, *i.e.*, molecular theory and study of the atmosphere, was given a high rank which seems to indicate that repetition which results in increased understanding need not be boring; (5) mathematical concepts were ranked low with the exception of the metric system.

Page [21] in a study of pupil opinion sought to discover how 60 high school seniors came to be interested in science. He listed the following findings: (1) science interests began anywhere from preschool up to and including the senior year with more students reporting they believed their interests started in 7th grade than in any other grade; (2) science interests originated through the science teacher more than any other source, with the general science course next in importance in spite of the fact that very few pupils rated science as their best liked course; (3) fathers gave more encouragement to science interests than any other persons and this was through provision of good science

books and magazines; (4) about 90 per cent of students reported they had hobbies which helped them learn more about science, nearly 100 per cent said certain magazines had been helpful, two-thirds felt their out-of-school jobs had been of value, more than one-third felt chemistry laboratory work had been the most interesting; (5) certain aspects of teaching such as the study of plants in biology and solving written problems in physics were judged to be a hindrance to the development of science interests but students desired an increase in laboratory work in biology, chemistry, and physics with more equipment as a needed improvement; and (6) the final consideration was concerned with the purposefulness of the science interest.

With few exceptions, the pupils reporting hoped to be working in some field of science in five years. The fields of science in which pupils hoped to be working ten years hence were the same as their present science interests. A majority of science teachers made no specific suggestions regarding further work or training in science; whereas, two-thirds of the students received suggestions from their parents regarding continuation of study.

Several implications seemed evident. Special attention should be given to junior high school science and to preparing competent teachers to handle it. Encouraging grade school pupils to "do things" with their hands would contribute to the development of science interests. Greater coordination of efforts between mathematics and science departments and between parents and teachers is in order. Provision should be made for classroom use of good science magazines and more laboratory work.

Research Related to Teaching Methods

Simon [25] set out to outline a basic philosophy for biology teaching and to indicate how this philosophy might be implemented. He conducted a library search on the subjects of philosophy, methods, and objectives of science education. He then proceeded, through a questionnaire sampling of 100 New York state biology teachers (1) to compare his views with those of practicing teachers, (2) to secure some insight into the implications of the methods used and concepts taught by today's biology teachers, and (3) to provide additional material and new ideas in such areas as teaching techniques and use of facilities.

He summarized the relationships suggested (no statistical analysis was used) as follows: (1) the concepts a teacher thought more important for his students to remember reflected his degree of progressiveness, and could be used as an index of his progressiveness; (2) those teachers rated by the panel as progressive were more likely to stress progressive concepts; (3) those teachers rated as progressive were more likely to use progressive methods in teaching biology; (4) respondents who use progressive methods had more students participating in science congresses; (5) teachers having smaller classes, teaching in rural schools and having fewer years of teaching experience tended to use more conservative methods of teaching, but these same teachers, however, tended to stress the more progressive concepts; (6) there seemed to be no relationship between the use of progressive methods and stressing progressive concepts. However, there was a relationship between progressive concepts and evaluation of methods. Those teachers who stressed the more progressive concepts tended to evaluate progressive methods as effective and conservative methods as not effective.

Abbott [1] made inquiries of over 100 schools, some from each state. He found that on the whole biology teachers leaned heavily upon charts and "pickled" specimens and made moderate use of permanent mounts. Living organisms were scarcely used in the biology laboratory.

Lucow [16] in a self-contained experiment examined the variances arising from two approaches to the learning of intro-

ductory high school chemistry. The statistical analysis involved the testing for significance of differences between variances in which Model II Analysis of Variance was used to determine the components. The teaching approaches were characterized as textbook-centered and laboratory-centered with the distinction being one of "emphasis rather than abstraction." The teaching methods were those which could be found in operation generally in Manitoba high schools where the experiment was conducted. The experiment was run separately for each of two populations; "accelerated" students who followed a college preparatory course and "non-accelerated" students taking a course not sufficient for immediate credit for university entrance. The examination used was developed from pilot operation over a period of a year and was valued at 216 points divided equally among three objectives: (1) recall of basic concepts, (2) application of concepts and principles, and (3) comprehension and interpretation. Pre- and post-examinations were used and increases in variances compared.

The results showed that "accelerated" pupils increased in variance as a group whether they were taught by the textbook or laboratory approach. The "non-accelerated" pupils profited more from the laboratory approach insofar as increase in variance of the group was concerned. The author recommended the laboratory approach be used for all pupils. This conclusion was based on a suggested postulate to educational philosophy that great variation in classroom achievement is evidence of the release of individual differences among pupils during the learning process.

Studies Related to the Evaluation of Science Instruction

Studies in this category fall into several classes: those relating to evaluation practices, those to determine the effects of science teaching on persons other than the the student himself, those involving the effectiveness of science instruction on student achievement, and a study to determine the effectiveness of the learning situation.

Summerer [26] and Telfer [27] in independent studies carried out significant and critical analyses of the New York Regents Examination in physics. Summerer made an item analysis and evaluated 1,682 completed examinations in physics for January and 2,142 for June 1949. He used a split-half coefficient of reliability which was calculated for the 50 item objective section of the examination. The total scores on this section were then compared with the scores on the 50 point subjective-essay section to arrive at a whole test reliability or "coefficient of consistency." Test validity was determined by comparing the scores made on the entire test with the score from those items from certain sections which were considered to measure the major objectives of science education as expressed in the 31st and 46th Yearbooks of the National Society for the Study of Education.

Telfer did some related work on 2,035 papers for the June 1950 Regents Examination in physics which provided added data on the examination practices. In addition to the above information an analysis was made of scoring problems and a check was made of the areas in the syllabus with which the examination dealt.

The conclusions from both studies indicated low reliability and validity for the examinations. Suggestions were made for retaining the examination practices with studies to be made to improve validity and reliability. The provision of a scoring key was recommended.

Fraser [9] employed a questionnaire, visited high schools, and held conferences with both administrative officers and science teachers to study the problem of whether high school science classes could contribute to solving community social problems as they are related to science teachers' objectives and attitudes toward using community resources in their teaching. His investigation showed the need for developing science teachers who feel confident in using

a variety of teaching materials, including community resources and data. A section of the questionnaire asked science teachers to indicate if certain community resources and data were available and used in their teaching. Teachers were also asked to indicate what value was attached to each kind of resource or datum regardless of whether or not it was employed in their teaching. Teachers were found to be using a variety of resources and data which were designed to assist in improving personal and community living. One of the recommendations of Fraser's study initiated the 1949 summer session Science Workshop for Teachers at Morgan State College. At the workshops, in-service teachers have focused attention on the development of some of the teaching competencies associated with science and personal and community problems. The evaluation of the workshop procedures indicated that participants have developed source units, teaching materials, and have planned learning experiences which were designed to improve the civic, social, cultural, and economic levels of living of people in the communities in which they teach.

Lorbeer [15] investigated the effect on parents of teaching a unit on atomic energy to high school pupils. Two schools supplied 273 pupils each; one group was taught the two-week long unit while no instruction was given in the other. Pre-tests and post-tests were given to both pupils and parents to determine if measurable changes in attitudes, interests, and understandings among parents would accompany comparable changes in their high school children. Lorbeer reported: (1) significant differences, as calculated by use of Fischer's "t" test, were found which would seem to indicate that substantial parent education had been achieved by the indirect teaching which resulted from the relating of information learned by the children to their friends and parents, (2) parents of the children instructed on atomic energy acquired significantly more new facts and understandings and altered some of their appraisals of this area than the parents of children not so taught, (3) although 21 factors, including such items as socio-economic status, scholastic achievement, intelligence rating, and religious affiliation, were isolated to see if any showed any significant differences, none did, and (4) data from files (subjective judgment) showed that the highest quartile of parents in gains made were much "closer" to their children than were the other three quarters.

White [30] sought the association between the student's evaluation of science as a subject and his accomplishment after study. Measures of accomplishment in science study and general mental ability employed were the *Cooperative General Achievement Test II; Natural Sciences, and A.C.E. Psychological Examination for High School Students, 1948 Form.* The 30-item science evaluation inventory was designed to determine pupil reaction to subjective and objective behavior relating to the study of science. It had a test-retest reliability of .90. The population under examination was composed of 332 twelfth grade pupils who were exposed to from one to four years of instruction in varying sorts of courses from 8 high schools. Statistical analysis included inter and multiple correlations and factorial procedures. The analysis of results point to the following inferences made by the investigator: (1) evaluation of science as a study is a factor that is related to accomplishment and operates in conjunction with mental ability both positively and negatively in relation to accomplishment; (2) on the same levels of mental ability, relative evaluation of science as a subject for study appears to influence accomplishment correspondingly; (3) on the same levels of science evaluation, accomplishment varies with the levels of mental ability. This indicates that mental ability is a limiting factor and science-value a delimiting factor in accomplishment.

A review of Mallinson's [18] two level study of the knowledge of botany possessed

by college and high school students may be found in the college research section.

Davis [8], assisted in evaluation and validation procedures by all members of NARST and by selected individuals from NSTA, AASA, and NASSP, selected seventeen factors to be used in determining the effectiveness of the learning situation in the public secondary schools of Ohio in the 1951–52 school year. In the same study the relative teaching effectiveness was evaluated using a sample of 40 teachers. In this aspect of the work the individual teachers were first rated for overall effectiveness and were then rated on the particular factors from the seventeen which were applicable to the teacher rather than to the teaching situation, school, pupil, or physical surroundings. Information was obtained from administrators, the State Department of Education, students, patrons and the teachers themselves. That the study was extensive is best indicated by the seventy-four statements of findings which defy condensation into the space available for this review. Some indication of their scope and nature may be gathered from several of the most pertinent recommendations. (1) Need was seen for study of programs of teacher preparation and of in-service programs of education for the science teacher, especially those in the profession who are incompetent. (2) There is need for improved programs leading to certification which would involve broader and deeper content preparation, greater attention to areas of child growth, and a program directed toward closer relationships between teacher and community. (3) Science education associations should redouble their efforts to make teachers acquainted with their benefits. (4) Boards of Education should select teachers of science on the basis of science teaching ability and preparation rather than on the possession of other abilities (coaching) by the teacher. (5) Boards of Education should increase budgets for science equipment and facilities.

Studies Concerned with Teacher Training in Science

The research in this area includes studies which are concerned with the competency of science instructors, the qualifications of teachers, the nature of science instruction in teacher training institutions and the trends in professional methods courses.

Whitehead [31], through the use of questionnaires to a selected group of teachers, sought answers to specific questions related to the general problem of "Who is Teaching Science in Texas?" There were nine specific questions concerned with the problems of academic and professional training, relationship of degree held and training received, the nature of the certificate held, academic preparation and course taught in the 1952–53 school year, status of teachers with regard to experience and tenure, membership in learned and professional societies, the nature of any trends regarding science teacher status and a comparison of Texas science teachers and those of other states and the nation. He concluded that Texas was lacking in competent science teachers and that the smaller high schools suffered most from this deficiency. It was found that present certification requirements do not assure that science teaching will be done by qualified teachers and that this was due both to inadequate certification requirements and to insufficient attention to standards when teaching assignments were made by school administrators. It was recommended that graduate training of science teachers include both academic and professional course work in equal amounts.

Warren [29] through a questionnaire sent to science teachers trained at Madison College, Virginia, determined the teachers' reactions to their education for their tasks and their opinions concerning other items pertinent to science teacher preparation. The teachers had completed 18 or more semester hours in a single science or combination of subjects and were teaching one or more science classes. The State Depart-

ment of Education also supplied data pertaining to science teachers and to the science taught in Virginia schools. An analysis of course offerings showed 50 per cent of the schools offered general science, biology and chemistry yearly with 95 per cent offering general science. It was also indicated that physics was not available in 80 per cent of the high schools of Virginia. Analysis also showed that 50 per cent of the teachers taught only one or two science classes more than 60 per cent only one class, and 85 per cent taught no more than two classes in science. More than 50 per cent of the teachers taught general science. The opinions expressed by the teachers indicated that they felt they needed training to qualify them to teach all sciences usually presented in high schools. They indicated that college science courses for teachers should be organized around problems of every day living and that education courses should be more practical with more time given to demonstration of good teaching. The instructors in educational courses should demonstrate the effectiveness of their theories in their own teaching.

An analysis of rural community needs was undertaken by Pisano [22] to determine how the secondary school science teacher could be of value in the satisfaction of the needs identified and to investigate the program of San Jose State College in terms of preparing teachers for meeting these needs. By questionnaire to adult organizations in rural communities, science teachers in these communities and faculty members at the college, data on the problem were collected. This material was then checked by personal interviews with a sampling of the respondents to the questionnaire. Ninety-seven significant community needs were identified. Science teachers were called upon and expected to help in such areas as pest control, sanitation, and street beautification. It was suggested that a broader science teacher training be given at the college and this training might include some general agriculture.

Adegbite [2] sought to identify the developmental tasks of Nigerian youth as they sought to prepare themselves for adulthood in a changing culture. These tasks were then examined for their implications for the improvement of the education of secondary school science teachers. An opinionaire was administered to 120 boys in the upper two secondary school classes of Baptist Academy, Lagos. The responses indicated a lack of mastery of developmental tasks and a need to make science teaching functional in order to help adolescents learn these tasks. The only category of tasks learned effectively was that of "acquiring information on physical phenomena." Little was accomplished for such developmental tasks as science interests, health information, vocational and sex education and preparation for marriage. The investigator recommended that a program of general education designed to achieve the objective of providing functional knowledge through the method of problem solving be designed and put into operation. A more adequate program of teacher education was also indicated in order to provide the secondary schools with teachers who could make science teaching more functional.

Walsh [28] caried out a nationwide survey concerned with the nature of science methods courses as taught in state colleges and universities. An instrument in the form of a questionnaire was validated by 19 professional educators and distributed to 261 institutions. Ninety-five per cent of the institutions solicited showed interest while 80 per cent returned completed instruments. His work was designed to (1) ascertain the general nature of currently offered courses, (2) reveal specific responsibilities as to personnel and requirements of the courses, (3) assess the equipment, facilities, and materials utilized in the course, (4) produce a composite description of the course, and (5) consider certain conclusions and implications concerning the course and its instructions in the light of recognized and established criteria. Only the implications of the study

are presented here. It was suggested that a two semester, 6 credit, course be used in training all science majors regardless of specialization since provision for subject or grade level specialty could be made as necessary, within the course as desired. This course should be a requirement both for college graduation and for state certification. Close cooperation between science and education departments should be sought in all efforts allied with the course. Suggested qualifications for the instructor included high school teaching experience, wide background of science experiences, and training in educational methodology. The instructor must become more familiar with secondary school teaching activities by means of direct observation to improve the relationship between theory and practice. Methods class instructors were urged to avail themselves of a wide variety of teaching procedures including guest speakers, high school laboratory demonstrations, and classroom observations. In addition to teaching for the usually accepted objectives, instruction should be given in the use of construction equipment to add to the personal qualifications of the science teacher. Although student and faculty opinion indicated the courses were valuable as taught, improved courses could be developed through follow-up studies and exchange of information.

Miscellaneous Investigations Related to Science Instruction

A set of possible reasons why some schools produce more Science Talent Search winners than other schools of comparable size and student ability was compiled from published studies. Bloom [5] used the selected New York schools (Forest Hills, Bronx School of Science, and Stuyvesant) and the Evanston Township High School of Evanston, Illinois, to arrive at these essential points from a summary of ways to assist in producing winners: (1) the evidence indicates that proper selection and motivation do encourage students toward professional careers in science since in the first 10 talent searches, 302 out of 400 student winners indicated they were influenced in this manner; (2) early identification of persons with above average capacities and scientific leanings is essential; (3) high I.Q. is desirable but not the determining factor with better than average reading skills, achievement record, and capacity to communicate also required; (4) cooperation and sympathetic understanding of many teachers are necessary; (5) manipulative skills with ordinary tools of the laboratory, indoctrination into the methods of science, and ability to observe and record are all factors in the development of the individual; and (6) opportunity of exploration through participation in extra curricular activity (club programs) is desirable.

MacCurdy and Bagshaw [17] investigated the judging of exhibits at a New England Science Fair. The ratings of judges of 41 senior and 55 junior division projects were the basis for these conclusions: (1) "an examination of the findings reveals variations in judgment which are so extensive they could not be called reliable or valid evaluations of the science qualities in the projects examined by the judge nor stated in the standards"; (2) "the positions which were assigned based on these judgments were dependent on these unreliable and invalid evaluations and would fluctuate wildly if less judgments were employed"; (3) "judges could be easily characterized as being high scoring, low scoring, or medium scoring, consistent or inconsistent as a result of their scores"; (4) "a revised score card with more exacting and objective standards and narrower limits has been constructed and offered as an instrument which is believed to help reduce the inconsistencies, variations, and poor judgments inherent in the one currently utilized."

Woodburn [32, 33] reported on the status of available materials and services regarding the encouraging of Future Scientists. The data were obtained by questionnaire

sent to high school teachers from which 455 usable replies were tabulated. Teachers were interested in sponsored career guidance materials but encountered difficulties in keeping informed on the availability of such items. By means of an inventory distributed to industrial organizations and educational institutions, information was received on sponsored programs and career guidance materials. A bibliographic listing was made available.

In Albuquerque, New Mexico, Harrington [11] determined the grade point average made by his pupils from high school records covering 20 years for a number of occupational groups. Included were "7,084 students enrolled in physics, chemistry, geology, physical geography, meteorology, and air navigation." Grade point averages for each occupational group made up of 10 or more pupils were compared. He provided a listing of these averages for each occupational group. The investigator concluded "the idea that the intelligence and talent of children is concentrated in the professions is a myth" and that scholarships offered to good science pupils from low income levels to cover only tuition or part of tuition costs are only down payments on things they cannot afford since far too frequently they are highly specific with respect to the college which must be attended and as frequently involve high travel expense and tuition costs.

Mallinson, Marburger, Miller, Osborn and Worth [19] in a committee report to the Central Association of Science and Mathematics Teachers combined the results of previous research studies and some original research to obtain answers to questions concerning science enrollments. It was reported that there has been a growth in the percentage of students taking generalized courses and a decrease in the percentage of those taking specialized courses other than chemistry. The committee's review of research indicated that the reasons for the decreasing enrollment trend might be, in part, the fact that teachers neglect to stimulate interest or to motivate in these areas since the intrinsic values of these courses may not be sufficient to motivate their election. In addition, the training of teachers may be causative since the academic programs for the training of teachers are not extensive enough; state requirements in academic courses are not extensive enough to improve the situation, and supervisory practices probably need improvement. In an original study in which 45 state departments of education responded, it was found that more emphasis was being placed on credits in English and social studies for graduation requirements than on science and mathematics. "It may be reasonable to infer that teachers of mathematics and science have not been so insistent in their demands for raising graduation requirements in these fields as teachers in other subject areas." A random sample of 139 guidance counselors from six Central U. S. states responded to a questionnaire concerning their undergraduate academic majors and minors. The results indicated that 65 had social studies majors and 92 had social studies minors. Seventeen had majors and 57 had minors in science. The committee suggested that although the facts do not indicate that guidance counselors are unsympathetic to science, it can be assumed that for students in doubt as to the selection of electives, their background is likely to influence the suggestions made. A list of suggestions relative to these findings was provided.

Summary

The secondary level committee selected for inclusion in this review a total of 34 studies. Those included from a larger number examined met the criteria of a broadly conceived definition of research. Twenty studies were published and appeared in 10 of the 41 periodicals examined. The remainder were abstracted from reports furnished by the United States Office of Education. The committee is of the opinion that more of the research should have been given wider circulation through

publication. It also feels that a greater number of periodicals should publish this kind of material.

The committee recognizes that its function of critical selection and review was made difficult because of the inadequacy of the reports available to it. There were frequent inadequacies in the statement of the problem, in definition of the population under study, in definition of the method of research employed, in description of the measuring instruments used, and in description of the statistical treatment employed including tests of significance, if any. While these faults were particularly apparent in the reports of unpublished studies, those appearing in the periodical literature were not without fault in many instances.

A dearth of controlled, statistically analyzed research was apparent and disconcerting. More of the studies could have been conducted in a manner which would have satisfied the criteria of scientific research. The problems were worthy of this sort of study and the implements for carrying them out are available.

It seems desirable to comment on the use of literature reviews and the use of questionnaires pertaining to practice and opinion as research techniques. The literature can hardly be assumed to be a field of knowledge to be reworked as an indicator of best or prevalent practice in science education. It is necessary to recall that the practices and opinions as stated in the writings may well be different from the far greater number which remain undescribed or unexpressed by the larger number of teachers who are responsible for the major portion of science instruction. Surveys of opinion and practice may be assumed to be valuable sources of information only when they are handled in a scientific manner. Even when so conducted, it is possible that they may contribute little more than a description of present conditions, for to assume that descriptions will contribute to an advancement in science education is predicated on the dangerous assumption that present practices and content were selected on sound bases.

In consideration of interest studies as a curriculum determiner, the committee feels that the time has come when more consideration and study should be made of the possibility and probability that the curriculum may be a determiner of interests and should be so considered. Research is needed to determine the extent to which the content and methods employed in science courses may contribute to the enlargement and development of interests.

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REVIEW OF RECENT RESEARCH IN THE TEACHING OF SCIENCE AT THE COLLEGE LEVEL III

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Biology

ANDREWS and Breukelman [3] studied the biology requirements in the general education program of 152 midwestern colleges and universities. A questionnaire was circulated among 189 colleges in fifteen of the central and midwestern states. Returns were received from 152 of these institutions. It was concluded that: (1) biology was more commonly a required general education course in teachers colleges than in liberal arts institutions; (2) all but one of the responding institutions had a science requirement, but the institutions requiring biology were in the minority; (3) the required biology courses were usually six or more semester hours in liberal arts institutions, and five or six hours in teachers colleges. These courses were usually taken by freshmen or sophomores in two semesters or three quarters; (4) both the biology majors and the non-majors took the same biology courses in liberal arts colleges, whereas about half of the teachers colleges had separate courses; (5) in both liberal arts institutions and teachers colleges, majors and non-majors were assigned to the same laboratory and lecture sections; (6) the principles-approach to biology predominated in all institutions, relatively more so in teachers colleges than in liberal arts institutions; and (7) plants were emphasized less than were animals, especially in the teachers colleges.

Hilferty [18] investigated the status of general biology in the teacher education institutions of New England. Data were secured by an examination of the literature, correspondence, interviews, and through questionnaires. The findings indicated that 85 per cent of the faculties had earned the master's degree and 28 per cent had received the Ph.D. degree. The teaching loads of this group were heavier than were those of other college teachers in the same institutions. About 35 per cent of these instructors had published articles in recognized periodicals. The course in biology was usually offered to freshmen, and averaged 1.9 semesters in length. Laboratory averaged 1.9 periods, and lectures averaged 2.3 periods per week. The principle objectives of the course were: (1) the development of an understanding of basic principles, and (2) the development of an understanding of the relationship of biology to life. Six of these institutions had no laboratories for biology; and the others, for the most part, were judged to be inadequate. Books on biology ranged from 29 to 2,500, with an average of 703. Periodicals averaged 11 with the range from 1 to 20. Only six schools had film libraries. The majority of the graduates of these institutions found the course helpful to them. Hilferty concluded that courses in general biology in these institutions were rather unsatisfactory and proceeded to give an excellent list of recommendations for improvement.

McWhither [23] employed a questionnaire to determine the status in course

content and methods in general biology in the general education programs of colleges and universities in seven southwestern states. A total of 353 questionnaires were circulated among 70 institutions. Returns were received from 237 officers of instruction in these institutions. It was concluded that: (1) general biology was a part of the general education program in 84.6 per cent of these institutions; (2) general biology was included as a part of the science requirements for general education in practically all of these institutions; (3) general biology was offered as a freshman course in most schools; (4) laboratory was a part of the general biology course in 80.6 per cent of the reporting institutions; (5) general biology was a one semester course for four semester hours of credit in the majority of cases; (6) 82.5 per cent of the biology instructors were men; (7) eighteen different texts were used in 53 of these institutions; (8) both science and non-science instructors felt that general biology fitted student needs in their general education programs better than did a more specialized course; and (9) most instructors felt the methods of teaching would vary with the instructor, the students, and the institutional needs, with no one "best" method to cover all situations.

Zipper [37] constructed and appraised an introductory biology course for Gannon College. The course was designed to implement the program of general education to the extent that the student might learn to use applicable knowledge in group action centered upon personal and community problems. He used the group process with students in thinking, discussing, planning, deciding, acting, and evaluating for purposes of attacking and solving common problems. The group process as used here showed promise in improved student-instructor relationships, wider use of community resources, economy of time, and provision for a wider variety of educational experience.

Elliott [13] constructed a rating instrument and used it to obtain from the staff of the Department of Biological Science at Michigan State College an evaluation of the content of the *Biological Science Lecture Syllabus* as it related to an understanding of the principles presented in the course. The data collected were used to suggest certain revisions of course material in terms of objectives, "minimum essentials" concepts, the preparation of examinations and laboratory studies, the lecture syllabus, and the study guide. It was concluded that (1) the lecture syllabus contained facts which contributed in varying degrees toward an understanding of the principles presented in the course; (2) the staff, acting collectively, was able to identify the factual elements of the course in the order of the importance of contribution toward an understanding of principles; (3) if equitable treatment of principles is a desirable feature of the syllabus, the need for revision of both the syllabus and the guide was indicated; (4) the study indicated areas where revision was particularly needed, and provided information concerning the general nature of the change; and (5) the content of the lecture syllabus did not adequately contribute toward the attainment of the course objective, namely, "to acquire knowledge of some of the basic laws (principles) of biology." It was further concluded that it was possible to marshall the factual elements of course content into orderly support of the major concepts and principles upon which the course was predicated.

Dietrich [11] provided specific suggestions for a course in introductory college biology, which was concerned with the study of living material. She consulted the literature including biology textbooks and laboratory manuals, current periodical literature, and theses for guidance in selecting materials for "living" biology. The course outline developed through her thesis could be adapted to local situations and would provide help to an instructor in overcoming the obstacles of limited time and space in

including living materials in courses in biology.

Winer and Paul [36] ascertained the reactions of students to a biological science course taught by (a) the group method, and (b) a lecture-discussion method. Two general education biology classes taught by one instructor were taught by both the group method and the lecture-discussion method for a half term each. The group were equated by ACE Psychological tests, Kuder preference scales, and the registrar's records. Responses were elicited from the students as to which method of instruction they preferred and their reasons for this preference. A forty-item check list was used to secure reasons. Major findings indicated that: (1) of the 51 respondents, 27 favored the group method, 24 the lecture method; (2) a general reaction of part of the group seemed to favor a compromise situation in which the main values of the two teaching procedures could be put to use; (3) students felt that the group method held more interest for them; (4) students felt that with the lecture-discussion method it was easier to prepare for tests, take notes, and learn factual material than in the group method; and (5) instructors found that the class rapport seemed much better under the group method than under the lecture-discussion method.

Myers [27] worked on the problem: "How can the field tour method of teaching biology be used in developing certain major objectives in biology instruction?" Field tours by means of busses visiting most of the United States and parts of Canada were used. Instruction was given in four major areas. Student-teacher planning in orientation, observations, student collections, lectures, reports, museum visits, summaries, use of references, interviews, and the publication of student reports were the activities engaged in during these tours. The educational benefits claimed for field tours were that direct student contact with the various parts of our country: (1) produced a more realistic and lasting understanding of plants and animals, agricultural crops, climate and conservation; (2) aided the student to make better observations on personal trips; (3) improved the teacher's classroom techniques in discussing problems related to the area covered on the tour; and (4) aided teachers to plan trips with their own students. It was claimed, also, that some of the techniques used in the field tour method could be adapted to trips made by elementary and high school students.

Silvan [32] studied the advantages of the problem approach in a specified area of general education biology. Examinations of the philosophy of general education, and of statements of an approach to subject matter selection were made to suggest methods of locating problems which could form the matrix of a general education course. Illustrative material was presented from entomology. It was concluded that it is possible to use subject matter in general education courses which is pertinent to the major problems facing students. It was recommended that: (1) instructors or class, or both, should analyze problem areas; and (2) that students' questions and discussions should be utilized in identifying and defining these problems.

Mallinson [24] investigated the types of errors in botany found in the papers of college and high school students. Data were analyzed from 4,000 regents' examinations in biology at the University of the State of New York, 1,000 Minnesota state board examinations in biology (1947 edition), 180 comprehensive examinations in science taken by students in six midwestern teachers colleges, 80 examinations in science and mathematics used by Western Michigan College of Education, and 100 of the author's classroom tests. It was concluded that: (1) the types of errors found on the papers of college students and on the papers of the high school students were much the same; (2) the major errors that appeared most frequently could be grouped under three headings: (a) errors involving "psychological ownership," (b) those involving "absolutism" and "relativism," and (c) those involving "selectivity."

Chemistry

Blick [6] investigated the relative effectiveness of three different schedule patterns in the teaching of general chemistry at the University of Connecticut. Pattern A consisted of two 1-hour lecture periods and two 2-hour laboratory periods per week; Pattern B, of three 1-hour lecture periods and one 3-hour laboratory period per week; and Pattern C, of two 1-hour lecture periods, one 1-hour recitation period, and one 3-hour laboratory period per week. Each pattern was tried out for one year over a three-year period. All classes were taught by the investigator. At the end of each academic year, the *ACS Cooperative Chemistry Test* was administered. Matched sub-groups were determined and compared on basis of results of the ACS Chemistry Test. The statistical treatment involved percentile, mean, standard deviation, multiple regression, analysis of variance, and Neyman-Johnson technique for matching sub-groups. The major findings were as follows: (1) student achievement under Pattern B was greater than under Pattern A ($t=3.54$); (2) student achievement under Pattern C was higher than under Patterns A or B. The difference in student achievement between Patterns B and C was not statistically significant at the one per cent level ($t=2.30$), while that between Patterns A and C favored Pattern C ($t=6.73$); (3) student achievement in the laboratory, as measured by the test used, was slightly lower under Patterns B and C than under Pattern A. As judged by the instructor and his assistants on the basis of written reports and results in qualitative analysis of unknowns, the three groups were essentially the same.

Gayer [15] studied the problems involved in coordinating quiz and lecture classes in freshman chemistry, especially in view of the relative inexperience of graduate student quiz instructors. A system was employed by which lecture classes were broken up into quiz sections, which were usually taught by graduate students who had little or no teaching experience. Quiz instructors were required to attend lectures, even though they had been over the work before. Brief lecture quizzes were given once a week. These were graded by the quiz instructors and formed the basis for the quiz section discussions. Most of the 25 per cent of the total grade which was allotted to the quiz section was based on these tests, and only a very small portion on the quiz instructor's judgment. The findings and conclusions of the study indicated that a very high degree of coordination between lecture and quiz section was achieved by this method, while at the same time, a heavy share of the actual teaching work was "farmed out" to graduate students. The inexperience of these graduate students was thereby minimized. The lecturer was enabled to maintain close control of the grading and even of the discussion. His approach and terminology were carried over into the quiz section discussions. The quiz instructor who did the best job in this was the more popular with his classes, and his sections showed the highest overall achievement and the lowest percentage of drops.

What experiments are most often required in college general chemistry? Lewis [20] secured data from college and university chemistry teachers and laboratory instructors, and used a questionnaire to find the answers to this problem. The major findings indicated that 150 experiments were used. No one experiment was listed by all schools reporting. The five most often used experiments were: (1) equivalent weight, (2) titration, (3) nitrogen and its compounds, (4) simple oxidation-reduction, and (5) molecular weight of a gas. Twenty-eight per cent of the schools responding reported use of semi-micro techniques in preference to the more usual macro.

To what extent can teachers compare their evaluation of class achievement with standardized tests such as the ACS cooperative tests, and how closely will the co-

operative test results coincide with an individual instructor's appraisal of a particular student? This problem was investigated by Brewer [8]. Two methods of comparison between the instructor's evaluation and cooperative tests results were used: (1) the latter grade average versus the cooperative test results, and (2) the 90 per cent confidence limits of averages versus the cooperative test results. Graphs and tables were employed. Sources of data were the instructor's evaluation (based upon his or departmental tests), and the results of the ACS Cooperative Tests given to all members (104) of the classes in qualitative analysis of a four-year liberal arts women's college over a five-year period. The statistical treatment involved confidence limits of averages, percentiles, and letter grade averages. The author found that the first method gives a good, general comparison between the instructor's appraisal and the ACS Cooperative Test results, but the second method is more useful if a more individual comparison is needed as in the case of a small class or an individual student.

Sampey [31] also investigated chemical research in liberal arts colleges in 1952. He used the *College Blue Book*, sixth edition, to establish liberal arts status of the colleges and determined the contributions of selected colleges to the periodical, *Chemical Abstracts*, for 1952. Fifty-one liberal arts colleges had 98 articles abstracted in *Chemical Abstracts*. Thirty-four of these colleges had one article each, while eight (Amherst, Brooklyn, Carson-Newman, Furman, Mount Holyoke, Oberlin, Richmond, and Wesleyan) accounted for a total of 45 articles. The results of this and other studies made by the author emphasize the fact that research in liberal arts colleges depends more upon the interest and initiative of individual faculty members than upon the standing or general reputation of the institutions in academic circles.

Do students in freshman general chemistry without previous work in high school chemistry have a higher failure rate than those students who have had a high school chemistry course? Thompson [34] circulated a questionnaire among a select group of colleges, and analyzed freshman grades in general chemistry over a period of five years at the Naval Academy. The rate of failure among those students who have not presented chemistry for entrance was much greater than for those who had had secondary school chemistry. The chances of failure were three to four times as great for those who had not had previous courses in chemistry as for those who presented it upon entrance. The chance of passing the general chemistry course "with distinction" as shown in Naval Academy data was four times as great for those students who had had previous work in high school chemistry.

Physics

Adams and Garrett [1] studied the relationship between achievement in various phases of scholastic background such as high school courses, college entrance tests, and first year college mathematics. The method used was finding the correlation coefficient (Pearson product-moment type) between the college physics grade and the grade in a specific scholastic phase. Grade marks such as A, B, C, etc., were converted to numerical values, 1, 2, 3, respectively. College entrance marks and ranks in high school classes were reduced to a percentile basis for purposes of calculating "r." The probable error of the correlation coefficient was also found. The subjects were 877 students who took a beginning physics course at Louisiana State University for two terms in either the 1947, 1948, or 1949 school year. The investigators concluded that: (1) articulation between college physics and various types of high school work was relatively poor; (2) despite this, high school records appeared to tell more about probable success in college physics than did entrance test ranks; and (3) a relatively high relationship ap-

peared to exist between achievement in college physics and in first year college mathematics.

Physical Science

Jensen [19] developed an up-to-date resource unit in atomic energy, including basic principles, applications, and implications for teachers and students of physical science. The major sources of the data for the study were reference books, periodicals, textbooks, and personal experience. He reported that "nuclear energy is at present not economically feasible, but may become an important source of power. The use of tracers is becoming increasingly important. Education for life takes on a new meaning when it is realized that our present students may have to make decisions in the future that may literally decide the continuation of civilization."

Balcziak [5] studied the relative effectiveness of the demonstration, the combined demonstration and the individual laboratory, and the individual methods of conducting laboratory work in a course in general education physical science. The method used was that of a controlled modern experiment making use of a 2x3 randomized blocks design and the techniques of analysis of variance and covariance. The experiment continued throughout the academic year and involved 144 students arranged at random into 6 sections. Three outcomes were measured: scientific information, scientific attitude, and laboratory performance. It was reported that significant gains were made under each of the three methods in science information and in laboratory performance. Only under the individual method was there a significant gain in scientific attitude. There was a significant increase in vocabulary on the laboratory performance test in one section of each of these methods. There were no significant differences in means among the several methods in the three outcomes measured.

Science for General Education

What type of educational program will aid people in becoming more democratic-scientific citizens? Prewitt [29] consulted faculty members, used reference books and periodicals, and proposed five criteria which described the institution of science and democracy. These criteria were compared, combined, and used as a basis for an educational philosophy and methodology in science education. It was concluded that the criteria, which for the study described the institutions of science and democracy, were fundamentally complementary and supplementary. Further, these criteria could be and were combined and used as a basis of an educational philosophy and methodology of science education. This philosophy and methodology was developed and stated. It was recommended that each teacher of science undertake to develop a philosophy and methodology of science education based on the institutions of science and democracy. This study could serve as a guide for such a program. The philosophy evolved could be used as a guide on any educational level of general, technical, or professional science education.

McGay [22] developed a useful pattern of educational theory for the general education teacher who possesses a special competence in the sciences, and formulated new types of educational experiences which were "better suited" to current needs than the experiences commonly found in college science classes. He studied the sociological, philosophical, and psychological factors which have brought about the demand for general education. He also studied the literature describing new science-related courses, and analyzed twelve of them to discover the kinds of experience which students have in these classes. Those educational experiences which seem best suited to helping young people in our society with their developmental tasks were suggested as appropriate for use by the general education teacher. It was concluded that a study of the developmental

tasks of young people, the present needs of society, and the facts of educational psychology suggests the need for new kinds of educational experiences in college science classes. A few of these new kinds of experiences were discovered in some of the science classes designed for general education. Study and analysis of these new experiences can constitute a useful orientation for the general education teacher.

Fraser and King [14] investigated the convictions of students and faculty at Morgan State College on certain topics which might be included in two general education courses in science. A questionnaire was employed containing 52 selected topics which might be included as a part of general education courses in science. The questionnaire was circulated among the general faculty and a select group of students for completion. Respondents were asked to indicate their convictions on the relative importance of the inclusion of the 52 items in general education science by checking one of three columns headed: "should be included," "should not be included," and "uncertain as to whether it should be included." The replies received from the students and faculty were tabulated separately for each of the three ratings, and the numbers were then translated into percentages. The percentages were then ranked. In the findings, the convictions of students on the 52 topics were compared with those of the general faculty. The most significant findings revealed in the total study follow: (1) students assigned the highest ranks to topics concerned with the life processes as they are displayed in man, current events in science, the contributions of science to the life of our times, and the role of the scientific method in solving problems; (2) members of the faculty placed a larger number of the 52 topics in the ten highest ranks than did students. These topics included all of those mentioned in (1), together with problems concerned with the influence of environmental factors on life, conservation of natural resources (including human), the nature and social implications of atomic energy, drug addiction and alcoholism, and, man's attempt to understand and control his physical environment; (3) there was little or no agreement between students and faculty on the topics receiving the six lowest ranks; (4) respondents suggested the two additional topics of bird migration, and science and human variability, for inclusion in general education science; (5) among reasons given for expressing uncertainty on the inclusion or non-inclusion of topics in general education science were lack of familiarity with topics; the inclusion of topics in other courses; lack of time in which to adequately develop the topic; topic not necessary for everyday living, and topic thought to be too controversial; (6) sixteen of 31 members of the faculty, and 23 of 49 students who commented on the development of mathematical competence indicated that the college should require a course in mathematics. These conclusions implied that the relative importance of the topics ranked for inclusion in courses in general education science should be considered in construct syllabi.

Randall [30] studied the performance of a group of selected college freshmen on the *National Achievement General Science Test*. The test was administered to 60 male and 85 female students at Southern University. These students were college freshmen from 51 public high schools and two parochial high schools in Louisiana, and two public high schools in Mississippi. High school science courses taken by these students were tabulated and a frequency distribution of test scores was made. Some attempt was made to individualize the results according to the achievement of the students in high school. It was concluded that: (1) the majority of the students had courses in general science, biology, algebra, geometry, and general mathematics; (2) a small number of males and females had had a course in physics; (3) more than half

had completed a course in chemistry; (4) less than 13.3 per cent of the males and less than 4.71 per cent of the females made scores equal to or better than the national norm of ninth graders in the ninth month of general science; (5) the majority had reached seventh-grade attainment in general science subject-matter mastery; and (6) students reflected little knowledge of physics, chemistry, biology, and the other physical sciences. Randall recommended that: (1) an introductory course in physical science be included in the general education program of the college; (2) an introductory course in biological sciences be included in the general educational program of the college; and (3) research studies in content be carried out for these courses.

On what basis could the general science requirements for the beginning college students be waived? How can results on matriculation tests in science and pre-tests used for the science course be interpreted? Glidden and Lindbloom [16] employed both the *Cooperative Achievement Test in Natural Science* and a locally constructed pre-test to investigate possible answers to these questions. The Cooperative Test was administered to students during the registration period. The pre-test was administered early in the term soon after classes were under way. Predictions were made as to the grades that students were likely to earn in the science course. About half of the grades were accurately predicted. The pre-test was a slightly better predictor. It is recognized that interests, study habits, general reading habits, and numerous other factors play an important part in the actual performance of students in the science course, and that prognostic tests do not measure these. Nevertheless, test results, used in combination with personal conferences, study of high school records and training, serve as a fairly satisfactory basis for determining which students may waive the natural science course and go on directly into chemistry, physics, botany, or zoology. While the correlation between performance on the *Cooperative Achievement Test in Natural Sciences* and the pre-test in natural science made locally was high, test results alone yield only about 50 per cent accuracy in predicting student grades in the general education course in natural science. Used in combination with other data, however, they contribute substantially in making satisfactory decisions as to which students should be permitted to accelerate by by-passing the general education course in natural science.

Newsom [28] investigated the status of courses in general education science in Methodist-related junior and senior colleges. Data were secured through questionnaires, textbook-analysis, personal correspondence, and visits to some of these institutions. He concluded that: (1) most of these institutions offered courses in science for general education; (2) 47 per cent of the courses were one year in length; (3) 36 per cent of the courses were one semester in length; (4) the classes were usually very large (45 students); (5) the course consisted primarily of physics; (6) 38 per cent of the instructors had earned the Ph.D. degree; (7) few instructors were employed to teach only general education science courses.

Thinking and Learning

How is thinking related to learning? Story [33] made an anaylsis of Dewey's conception of thinking as the integral element in the educative process. It was concluded that the first requisite in learning is a personal problem which demands thinking. This makes activity a requirement because problems arise only when the learner is doing something. Then, conjectures are formed and facts and ideas are carefully manipulated and organized in proposing a plan of action for solution of the problem. Then, the ultimate and essential action becomes a check on the rightness or quality of thinking and determines experimentally the final important issue, i.e., the effectiveness of thinking, which is the actual measure of learning.

Morgan and Morgan [25] sought to determine whether untrained subjects can think logically. Logic was defined as the "principle" that enables an individual to make judgments or conclusions consistent with the data at hand. The authors were really taking exception to A. Miller's statement which appeared in the chapter on Speed and Language in *Steven's Handbook of Experimental Psychology,* page 806. "The fact is that logic is a formal system, just as arithmetic is a formal system, and to expect untrained subjects to think logically is much the same as to expect preschool children to know the multiplication table." The Morgan "Test of Logical Reasoning" was administered to 134 adults, all employed by the U. S. Government. The subjects were divided into two groups: (1) those who never had a course in logic (WOL), (2) those who had had a course in logic (WL). In each group there were 58 males and 9 females with a mean age of 27 years (SD of 5), the oldest being 42 and the youngest, 20. It was found that: (1) in group WL, the lowest score was —2, the highest 67, with the mean at 29.1, and an SD of 14.0. In group WOL, the lowest score was —7, the highest 48, with the mean at 21.2, and an SD of 11.2. The means were significantly different beyond 1 per cent level. Since the test was scored right minus wrong, a person's guessing throughout would earn for him a 0 score. The WOL group was able to get a mean of 21.2. (2) In the majority of cases, college graduates who had had at least three semester hours of college training in logic, obtained higher scores on the test of logical reasoning than did college graduates who had not had a course in logic. (3) Professor Miller's hypothesis that untrained subjects cannot be expected to think logically was not substantiated because (a) 38 per cent of WOL's obtained higher scores than paired partners of WL's; (b) WOL's did 73 per cent as well as the WL's; (c) WOL's with Ph.D.'s obtained higher scores than B.A., M.A., and LL.D. WL's. (4) Professor Miller's hypothesis might be restated to read, "In the majority of cases, untrained subjects cannot be expected to think as trained subjects."

Cranwell [10] studied the responses of college students to a questionnaire of animistic thinking. He made an attempt to "verify the observations" of Dennis (*Scientific Monthly,* 76:247 (1953)) that "as many as 54 per cent of college students . . . accept as having the property of being alive many classes of objects which certainly do not have that property according to any scientific definition of life." Dennis asked college students to state whether certain objects were alive and to explain their answers. Cranwell constructed a series of ten multiple-choice items. Five of the items permitted "the respondents to select among animistic and non-animistic responses." Three of the items were "taken from the study by Dennis, and the highly animistic alternatives were paraphrased from statements actually made by his subjects. The questionnaire was administered to 163 students in psychology courses and 40 students in second-year zoology." "In the psychology sample, 58 students (35.6 per cent) selected one or more of the alternatives considered animistic. In the zoology sample, 11 students (27.5 per cent) made a similar selection. If to these cases are added those who seem rather doubtful of the true distinction, then two per cent become 54.0 and 52.5, respectively. The results substantiate those by Dennis, and leave little doubt as to the fact that a distressingly large proportion of our college students are unable to make a precise discrimination with regard to the nature of life. . . . More animistic responses occur among the advanced zoology students than Dennis' data on biologically trained students would lead one to anticipate." This is quite possibly due to the greater tendency of students to be led off the track by multiple-choice items. "Here we have evidence that a significant minority of our college

students have not even learned 'what life is all about.'" The size of the sample, both of questions and of students, used by the investigator was not large enough to make this a major study. However, it does point to what may be a serious failure in communication between college biology instructors and their students and thus poses a problem suitable for a more ambitious piece of research.

Dunning [12] identified the steps by which a classroom teacher of science can construct his own tests to measure certain aspects of critical thinking, and gave suggestions on how scores obtained from these tests may be interpreted. While most of the examples used in this paper as illustrations were drawn from the secondary school sciences; the methods described are equally appropriate to the college level. The author points out how to test the student's ability to judge which principles and facts support and which do not support a conclusion in relation to a given situation. In summary the student was required to judge whether or not the conclusion was tenable in the light of the statements he had considered. Using the key: True, Probably True, Insufficient Evidence, Probably False, and False, the author showed how an insight can be gained into the student's thinking as to whether it was generally accurate, too cautious, inclined to go beyond the data, or usually in error. The tests illustrating the nature of proof showed how to measure the student's ability to distinguish relevant facts from irrelevant facts, necessary assumptions from unnecessary assumptions, and facts from assumptions. It was concluded that: (1) most testing techniques commonly used measure only the acquisition of factual information, mainly because construction and validation of tests to measure higher level objectives are difficult to construct and validate, and this article showed (2) how critical thinking can be measured and the test scores interpreted in a meaningful way.

A study to determine the advisability of utilizing textbook errors as a means of encouraging students to develop scientific attitudes, was conducted by Morrell [26]. The method used in this study involved classroom experimentation in which students reported textbook errors to the instructor. The first student reporting a given error was given bonus credit towards his final grade. Students were asked about the effect of the policy on their study habits and attitudes. The statistical treatment involved correlation of grades with bonus received, the number of errors detected, and the number of students whose grades were raised by the bonuses, and correlation of student responses on questionnaires with bonuses received. The majority of students felt that the policy was undesirable; however, there was a definite correlation between the number of errors found and the expressed improvement in effectiveness of study. Also, a minority indicated they studied longer because of the bonus. There was a correlation between the time spent and the errors reported. Most students felt that the practice made them more critical of textbooks. Those who found the most errors tended to be the better students. Students who found errors tended to favor the policy.

Future Supply of Scientists

Bowles [7] reported on the trends in the future supply of scientists in the United States over the next twenty years. His article on "The Future Supply of Scientists" was an amplification of a memorandum prepared for a conference of the National Science Foundation in August of 1953. The author made a synthesis of population studies related to the college entrance age groups, studies on college and graduate school enrollments, and a study of student success in completing degree programs in the graduate school. His major findings in the form of conclusions were: (1) in 1951–52, the 18-year-old age group numbered 2,114,000; of this group, 436,000, or 19.5 per cent of the age group,

entered college; 64 per cent, or 265,000, are expected to graduate from college; the number of this group receiving doctor's degrees can be estimated at 5,300 to 6,000; (2) the group who will be 18 in 1969–70 will number 3,364,000; it is estimated that 912,000 will enter college; 656,000 will graduate from college; 16,000 Ph.D.'s will come from this group; (3) the age group (18-year-olds) will have increased slightly more than 50 per cent during the period 1951–1969. However, the percentage of increase of persons of the 18-year-old group expected to take the Ph.D. has increased very little over this same period (1952—not less than 2 per cent, nor more than 2.3 per cent of college graduates taking the Ph.D.; 1969—not less than 2.4 per cent of college graduates taking the Ph.D.); (4) if present trends continue, 55 per cent of the 16,000 Ph.D.'s estimated for 1975, or 8,800, will be scientists. This is to be compared with 4,200 scientists graduated in 1952; (5) most of the doctoral training is now done in sixty institutions; (6) there is evidence that in the next twenty years one hundred or more undergraduate colleges will be organized. There are no signs of any substantial increase in the number of graduate schools; (7) at present, one-fifth of those who possess doctoral ability go on to doctor's degrees (including medicine); (8) at the present, there is a trend of fewer science teachers teaching more students. If this trend continues, the nature of instruction in science is almost certain to change. This could result in an alteration downward of the above projected trend of doubling our supply of scientists in the next twenty years.

Prediction of Academic Success

Arn [4] at the University of Washington studied: (a) the probable improvement in prediction of first-year academic success in ten selected science areas which the addition of three reading test variables might make over the eight predictor-variables already developed by others; (b) whether the work and time factors in multi-variable predictions can be shortened with no loss in accuracy; (c) which of three regression equations yielded the most accurate predictions in the ten selected areas; and (d) the comparative accuracy of the eleven predictor-variables over the eight predictor-variables in the predicting of first-year university grades. Data were drawn from other statistical studies made at the University of Washington. Using the Multiple Regression Method, the three regression equations, and a comparison of the relative accuracy of the regression equations, Arn's principal conclusions were: (1) the Multiple Regression Method is practical and accurate and overcomes the main objections to adding predictor-variables; (2) differential prediction (in selected areas) promises better academic adjustment and greater reduction of failures; (3) the addition of three reading test variables to the regression equations based on eight predictor-variables did not improve the original predictions by an appreciable amount; (4) the substitution in the regression equations of the independent, in place of the criterion, means and sigmas did not affect the accuracy of the predictions; and (5) a periodic evaluation of the regression equations will be essential as the validities of the variables involved change.

Coleman [9] administered a trial battery of tests to entering freshman engineering students as they entered college from high schools at the University of Tennessee. Grades were tabulated for this group from the fall quarter 1950, through the fall quarter 1951. Instead of using the mean point hour ratio for all courses combined, correlation coefficients were computed for the various tests with grades in the courses in the freshman engineering curriculum. It was concluded that: (1) coefficients were not especially high, but several of them were sufficiently so as to be regarded as useful for selection or guidance situations; (2) the best predictive instrument in the battery used seemed to be the *Cooperative Algebra Test*; the *Cooperative English Test* ranked

second; (3) the *Bennett Mechanical Comprehension Tests* tended to get better correlations with grades than either of the ACE scores among freshman students; and (4) it was also found that the *Minnesota Paper Form Board* was not adequate.

Long and Perry [21] evaluated the effectiveness of high school averages and scores on entrance examinations as a basis for predicting four-year grade-point averages in the School of Technology of The City College of New York. Two additional facets of the investigation were: (1) to study the relationship between the four-year college grade-point average and ratings on two standard interest questionnaires (Strong *Vocational Interest Blank* and the Kuder *Preference Record*), and (2) to compare scores on Kuder for students as freshmen and as seniors. The results reported were based on data obtained on students graduating from the School of Technology and The City College of New York in 1951. Intercorrelations along with means and standard deviations for the variables were made between the four-year college average, high school averages, and the scores on three tests entering into the composite score. Using the weighted grade-point average based on four years of college work as a criterion, the results of this study indicated that the selection of freshman engineering students can be improved by the use of both high school averages and test scores. The effectiveness of tests of scientific verbal ability, comprehension of scientific materials, and general mathematical ability was investigated. The correlations found between two interest questionnaires (Strong and Kuder) and college grades were not high enough to warrant the inclusion of ratings on such questionnaires in a selection battery, but it was felt that such instruments are useful in an individual counseling situation.

Education of Science Teachers

Warren [35] studied various conditions and problems connected with the education of high school science teachers at Madison College and drew implications from these conditions and problems for recommending changes in basic organization and fundamental policies. A questionnaire designed to obtain the reactions of teachers as to their education for science teaching and their opinions on other items pertinent to the preparation of science teachers, was sent to Madison College graduates who were teaching one or more classes in science and who had completed at least 18 semester hours of work in biology, chemistry, geology, or physics, or in a combination of these subjects. Additional data were secured from the State Department of Education, from pertinent literature, observation of teachers and students, and conferences with high school personnel. These data concerned subjects taught, teaching combinations, science loads, and high school offerings. The findings and conclusions indicated that fifty per cent of Virginia high schools had a minimum science offering of general science, biology, and chemistry each year. Most of the science classes were taught by teachers who were devoting the major portion of their instructional teaching to other subjects—a very undesirable situation. Eighty per cent of the Virginia high schools did not offer physics. Madison College graduates indicated the following needs: broad training in the field of science, preparation organized around problems of everyday living, use of scientific method in actual social context, practice in improvising equipment, health, teaching techniques, competence in social science, more practical work in educational psychology and education courses, and demonstration of good teaching methods by their instructors in their own classes.

Hart [17] attempted to determine the optimum balance between the general and specialized courses which will best prepare the graduates of Lafayette College for careers in science (chemistry).* (1) All

* Inclusion of this study by Hart under the heading "Education of Science Teachers" may be questioned.

Ph.D. graduates and candidates of Lafayette were requested to evaluate their undergraduate training; (2) the heads of representative graduate departments of chemistry in selected universities were questioned and asked to state their opinion as to requirements and suggested curricula to best prepare students for graduate study; (3) a survey was made of the requirements for admission to graduate school by a study of catalogues of 11 representative universities; (4) some attention was devoted to the requirements for accreditation of graduates by the American Chemical Society; (5) an evaluation, by questionnaire, of undergraduate training was sought of alumni who entered industry upon graduation; (6) a comparison was made of the B.S. degree in the chemistry curriculum with those of other high ranking colleges and universities; and (7) the opinions of industrial personnel officers were sought. Some of the recommendations for curricular change as secured from these procedures were: (1) a second foreign language; (2) a second course in physics; (3) a course in advanced inorganic chemistry; (4) a course in theoretical organic chemistry; (5) increased instrumentation in quantitative analysis; (6) a course in communications (oral and written reports); (7) an increase in the humanities (the four-year curriculum at Lafayette contained 25 per cent humanities; although not out of line, this percentage was slightly lower than that at other comparable institutions). Some of the recommendations for administrative change as secured from the above procedures were: (1) greater stress on reading, writing, and thinking in a logical fashion, (2) more preprofessional guidance, (3) greater liaison between the college and industry (it was reported that the present generation of college graduates have a "from cradle-to-grave" philosophy), and (4) more research work by members of faculty.

Allen [2] investigated the advantages and disadvantages for teacher education of "direct observation of classroom teaching by means of television in contrast to the usual classroom visitation." An in-school closed circuit televising system was set up in six classrooms of the University of Wisconsin's Summer Laboratory School, a public school in Madison. For three consecutive mornings, from 9:30 to 11:00 o'clock, the cameras observed activities, two each morning, in six classes, including kindergarten activities, French lessons in the first grade, social studies and a film in the second grade, science in the fifth-sixth grade, and remedial reading demonstrations. A group of student-, and other teachers witnessed the classroom activities through proper receiving apparatus in the school auditorium. Each morning at 11:00 o'clock, the production staff and participating teachers held a panel discussion on the morning's activities. On the basis of comments of the observers during these discussions, as well as of personal conferences with individuals, the author concluded: (1) there was general agreement that teacher education could greatly benefit from televised observations of classes although concern was expressed as to abrupt changes of the camera from one activity in a room to another; (2) although most of the participating teachers adjusted to the distraction of the cameras, a few of the participating teachers were definitely disturbed; (3) the children were distracted by the cameras and crews but "no more so than on the first day that a group of visitors enters a classroom"; (4) production and the technical problems were fairly easily solved although satisfactory sound pick-up and pupil seating arrangements were among the more serious difficulties. As implications of these conclusions, the author recommended that: (a) the camera should be focused upon a particular scene or activity until its culmination, rather than being continually moved; (b) only those teachers who have a definite interest should participate in a televised class activity; (c) enclosed runways with one-way vision

glass be built into demonstration classrooms; and (d) "this television method of classroom observation be a valuable supplement to (not a substitute for) actual classroom visitation by teacher education students."

Critical Evaluation

The total impact of the research reported in this review seems to indicate a continuing need for: (1) the re-examination of operational definitions of research, and (2) the determination, more critically than in the past, of the real status of research in science education. There seems to be a definite need for motivating a larger number of college teachers to do research in the teaching of science. The limited number of investigations reported for the college level is disturbing, especially in view of the fact that: *all college teachers of science are in a sense science educators, and presumably are vitally concerned with the improvement of instruction.*

Some of the recommendations encountered are of general interest and should be read and pondered by all who teach science; others illustrate by actual examples how higher level objectives can be tested. It was encouraging to note in the several investigations emphasis upon: the redetermination and evaluation of curricular and course materials; methods of teaching; scientific method; the education of science teachers; status and requirements; articulation; productivity; philosophy; the prediction of academic success; future supply of scientists; enrollment; examinations; trends in teaching; and audio-visual aids, especially television.

The techniques employed, in some of these research studies, indicate a need for further refinement of the general and statistical methods of such investigations. Some of these studies appear to be questionable in value and do not seem to be particularly important when judged by the findings. As such, they are not regarded as contributions of enduring significance and substantial worth.

These comments are in no sense a condemnation or criticism of the total research being reviewed. There has been, on the whole, marked progress toward a greater refinement of the general and statistical methods of investigation and the associated higher level of scholarship. It is hoped that this critical evaluation may serve to point out some ways by which research may contribute more realistically to the improvement of science teaching in colleges. This research might be centered in the following:

1. What has been learned about research in the teaching of science at the college level? How can this contribute more realistically to the improvement of science instruction at this level?

2. What do we need to find out about the teaching of science at the college level?

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SCIENCE EDUCATION RESEARCH STUDIES—1954

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SCIENCE Education Research Studies—1954, a cooperative project by the National Association for Research in Science Teaching and the Office of Education, summarizes seventy-three research studies in science education.

Report forms were mailed to research leaders in science education early in 1955 requesting data on the research completed during the calendar year 1954. Wherever possible, each summary contains the following information: author, title of study, degree (if a thesis), faculty adviser, year study was completed, source from which a copy of the study may be obtained, problem studied, procedures, and findings and conclusions. The statements of conclusions and findings in the summaries of research studies are, with few exceptions, those reported by the author. In this report there is no attempt to evaluate the quality of the research. Arrangement of summaries is alphabetical by author's surname.

Similar summaries of science education studies were compiled in the years 1951–1954. Single copies of the summary of research completed in 1950 and 1951 may be obtained by writing directly to the Publications Inquiry Unit, Office of Education, U. S. Department of Health, Education, and Welfare, Washington 25, D. C. The summary of research studies that were completed in 1952 is no longer available. The summary of studies completed in 1953 was published in the December 1954 issue of *Science Education*. Any of the summaries may, of course, be freely duplicated by anyone wishing to do so.

Any persons who know of studies on the teaching of science which were completed during 1954 and which are not included in this circular are urged to bring them to the attention of the Office of Education. These studies will then be included in a future listing.

ADRAGNA, C. MICHAEL. Prediction of Achievement in Junior High School General Science. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Professor Cyrus W. Barnes.

Problem.—To determine the significance of the variables of sex, grade placement, arithmetic development status on the individual order of rank according to final general science scores, both separately and in all possible interacting combinations for purposes of estimation and prediction of achievement in junior high school general science.

Procdures.—The 54 pupils for this investigation, 18 from each grade, were chosen randomly from approximately 500 pupils of grades seven, eight, and nine of five New York City junior high schools. The initial general science test was administered in September and the final general science test was given the following June.

Major Findings and Conclusions.—Achievement in general science in the New York City junior high schools is not significantly affected by any interacting combination of sex, arithmetic development status, and grade placement when the effects of initial general science scores and mental ages are considered. The variables of sex, arithmetic development status, and grade placement are singly significant, and hence, are potential predicators of achievement in New York City junior high school general science after the effects of initial general science scores and mental ages have been eliminated.

* * *

ALBERTI, LEO. An Investigation of the New York State Regents Examinations in Chemistry for June 20, 1950. M.A., 1954, University of Michigan, Ann Arbor.

Major Faculty Adviser.—Dr. George G. Mallinson.

Problem.—To item analyze and evaluate 1,925 completed and graded Regents Examinations of the University of the State of New York in chemistry for June 20, 1950.

Procedures.—The following procedures were used in the study: (1) the tallying of scores obtained by students on the examinations, (2) determination of the reliability, consistency, and validity of the Regents Examinations, and (3) an item analysis of the Regents Examinations in chemistry.

Major Findings and Conclusions.—The data show that the Regents Examinations in chemistry for June 20, 1950, are more reliable than teacher-made tests and more valid in its measurement of principles than teacher-made tests, but the data fail to show that the test is consistent or valid insofar as problem-solving measurements are concerned.

* * *

ANDERSON, KENNETH E., MONTGOMERY, FRED S., SMITH, HERBERT A., AND ANDERSON, DOROTHY S. Toward a More Effective Use of Sound Motion Pictures in High School Biology. 1954, University of Kansas, Lawrence.

Problem.—To compare pupil achievement in biology when films are used and when they are not used with traditional class procedures.

Procedures.—Three groups were established as follows: Group I. A control group in which no films were shown or in which the teachers showed some films of their own choice. Group II. An experimental group in which students saw the films at intervals throughout the school year. Teachers in these classes made their own preparations for the showing of the films. Group III. An experimental group which saw the films at intervals throughout the school year bolstered by emphasizing the principles *covered* or *stressed* in each film.

Major Findings and Conclusions.—There was some evidence that the Films-with-Principles-Stressed Method yielded results somewhat superior to the Film Method, and that the Film Method yielded results somewhat superior to a conventional method as used in Control Group. This study has indicated that a choice of films in harmony with the objectives of instruction in a particular academic area is capable of yielding superior results in learning if the proper choice of films is accompanied by realistic film utilization which emphasizes selected objectives of instruction in an academic area. Since only one objective of instruction was selected for emphasis in this study, it is to be expected that film-utilization plans which cover all of the major objectives of instruction in an area will produce even greater learning on the part of students in science and other areas of instruction.

* * *

ANFINSON, OLAF PETER. The Refinement of Objective Tests for Non-subject Matter Goals of Science Courses in College General Education Through Statistical Analysis. Ed.D., 1954, Colorado State College of Education, Greeley.

Major Faculty Adviser.—Dr. Donald G. Decker.

Problem.—To determine whether or not teachers who are now teaching science courses in our schools could produce valid and reliable instruments for measuring the status of students with regard to non-subject matter goals of science courses in college general education.

Procedures.—The instruments of educational measurement used were produced by teachers in a seminar in science education at Colorado State College of Education during the summer session of 1951. Preliminary forms were used in general education classes at the Colorado State College of Education, and later the forms were used in general education classes in three midwestern colleges.

Major Findings and Conclusions.—The teachers, who were members of the 1951 seminar, demonstrated the ability, as a group, to produce valid and reliable instruments for measuring the behavior of college students with regard to non-subject matter goals in courses of science for general education. The general methods used by the seminar group in creating and refining the test instruments described in this study are recommended for use by similar groups.

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BAKER, RUSSELL D. A Study of the Achievement of the Students at Weaver High School in the Field of Natural Sciences. M.S., 1954, University of Connecticut, Storrs.

Major Faculty Adviser.—Dr. David J. Blick.

Problem.—To analyze the achievement of the students of Weaver High School, Hartford, Connecticut, in the field of natural sciences.

Procedures.—A general science proficiency test was given to 272 seniors at the school in May 1953. The background of the students was obtained from the permanent record cards on file in the principal's office.

Major Findings and Conclusions.—The mean scaled score achieved by the students of the Class of 1953 at Weaver High School on the Science Proficiency Test is slightly, but significantly, higher than that of the 3,900 students used to determine the national norms for the test. The achievement of the boys taking the Science Proficiency Test is significantly higher than that of the girls as measured by the test used. Although the boys take more science courses than the girls, the study shows that the mean scores of the boys and girls who have studied science for the same number of years show no significant difference in science achievement.

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BECK, RALPH LEA. Planning a Student Teaching Program for Prospective High School Science Teachers. Ed.D., 1954, New York University, New York City.

Major Faculty Adviser.—Professor Cyrus W. Barnes.

Problems.—(1) To identify superior policies and practices in student teaching programs in science at the high school level in Ohio. (2) To propose a student teaching program for prospective high school science teachers based on the findings of this study.

Procedures.—Data for this study were obtained through the use of three forms of a questionnaire and through personal interviews. Thirty-two of the 44 colleges and universities in Ohio, which had students enrolled in student teaching in science in the academic year 1952–53, participated in this study.

Major Findings and Conclusions.—Supervision of student teaching is a minor part of the assigned duties of college and university staff members reported in this study. A school with an enrollment of 800 or fewer pupils in the upper six grades, with three or fewer student teachers assigned in science, is the typical high school which was utilized for student teaching in Ohio at the time of this study. Opportunities for professional laboratory experiences on the part of student teachers, aside from classroom teaching, are, in general, very limited. Student teachers are relatively free in the selection of methods of teaching and in the selection of instructional materials in the courses which they teach. Frequent, unscheduled, follow-up conferences between supervising teachers and their student teachers are common. College and university supervisors, in general, observe their student teachers in science from three to five times during their student teaching assignments and hold as many conferences with each student teacher. Follow-up conferences, in general, are of about 30 minutes duration.

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BEELER, NELSON FREDERICK. A Critical Examination of the Use of Analogy in Science Writings for Children. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Professor Cyrus W. Barnes.

Problem.—The study tested the hypothesis that several aspects of the use of analogy in science writings for children have changed during the years and that these changes parallel changes in educational procedures.

Procedures.—Four chronological periods were established based on discernible changes in the procedures suggested for elementary science in the schools. The periods encompassed the time from 1800 to 1952. Fifty textbooks and trade books representative of each of the periods were selected for analysis.

Major Findings and Conclusions.—The 6,829,000 words of text which were read produced 8,162 analogies, which was an average of one analogy for each 835 words and 41 analogies per book. About two-thirds of the analogies read were judged to have referents which could be experienced by children either universally or commonly. Infrequent analogies made up about 5 per cent of the total. No defensible trend in the use of analogy could be discerned. The incidence of analogy, as it was delineated under the three aspects through the four periods, was erratic. Furthermore, the effect of an excessive use of analogy in one or two particular books of each period was found sufficient to change the pattern of the employment of analogy markedly. The original hypothesis was, therefore, declared unsupported.

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BRANDWEIN, PAUL F. The Gifted Student as Future Scientist. 1954, Forest Hills High School, Forest Hills, New York.

Problems.—To describe (1) a program that is desirable for the pupils with high ability in science, (2) the reactions of the pupil while in the program, and (3) the kind of teacher needed to teach the gifted.

Procedures.—The study is based on a survey of the literature in the field and the author's experiences in teaching the gifted.

Major Findings and Conclusions.—The author develops a working hypothesis for determining the nature of giftedness. He describes a program he found successful in teaching science to the gifted. Characteristics of a teacher of the gifted are listed.

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BROWN, DONALD GORDON. A Resource Unit on the Conservation of Natural Resources for the Course in Washington State History, Government, Industries, and Resources for the Seventh Grade of Shumway Junior High School, Vancouver, Washington. M.Ed., 1954, University of Washington, Seattle.

Major Faculty Adviser.—Dr. Alice H. Hayden.

Problem.—To provide the seventh grade teachers of Shumway Junior High School with a resource unit on conservation of natural resources.

Procedures.—A study was made of the available literature on conservation education.

Major Findings and Conclusions.—The resource unit consisted of five parts that may be used separately or in combination and included separate sections on mineral, soil, forest, water, and wildlife conservation. The extent and location of natural resources were included. Misuse and poor management practices were emphasized. The many benefits derived from natural resources were presented.

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BULL, GALEN WILLIAM. The Activities and Backgrounds of Pupils with Dominant Science Interests. Ed.D., 1954, University of Missouri, Columbia.

Major Faculty Adviser.—Dr. Ralph K. Watkins.

Problems.—The purpose of this study was to analyze the backgrounds and activities of high school pupils who showed some unusual interest or activity in some phase or application of science and to determine insofar as possible what the conditioning experiences were that seemed to be instrumental in the development of a science interest or hobby.

Procedures.—Case history studies were made of 100 high school pupils having dominant science interests and hobbies and who were recommended by their science teachers.

Major Findings and Conclusions.—(1) Most pupils having dominant science interests and hobbies developed these interests at an early

age. (2) The large majority of pupils with dominant science interests and hobbies are superior in scholastic ability to the normal pupil in the same schools. (3) Three-fourths of the pupils with dominant science interests and hobbies have a preference for interests and hobbies involving physical science. (4) Nearly all pupils with dominant science interests and hobbies tend to have good social poise and are not classified as unusual in social behavior. (5) Approximately 60 per cent of the pupils with dominant science interests and hobbies are inclined to avoid the usual physical activities found in the typical secondary school. (6) All the pupils with dominant science interests and hobbies are readers of science literature. (7) Pupils with dominant science interests and hobbies are encouraged by parents or science teachers in their interests and hobbies.

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CAMPBELL, JAMES ARTHUR. Chemical Education in England. 1954, Oberlin College, Oberlin, Ohio.

Problem.—To study the education system in England with particular reference to chemical education.

Procedures.—The study is based on ten months' study at Cambridge and visits to schools in England.

Major Findings and Conclusions.—The author suggests that our present system of mass education should be enlarged and also that the gifted should receive special attention at an early age.

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CARLIN, BENJAMIN B., DEL SANTO, LOUISE M., GORDON, JOHN L., JOHNSON, CHARLES H., AND NASH, MALCOLM F. Reactions of Selected Pupils on Inquiry Forms and by Personal Interviews Seeking to Discover Present Interests and Attitudes in the Science of Their Own Age Level. M.Ed., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problem.—To find if there is any significant difference in the abilities of pupils at various grade levels that will identify science minded students.

Procedures.—Thirty-six students having I.Q.'s of 120 or better were selected. As far as possible matched pairs of students who were interested in science and those who were not interested in science were selected by the writers. Each of these students was administered a battery of tests—Kuder Preference Test, Spaulding Picture Preference, Bell Emotional Adjustment Inventory, Read General Science Test—and an oral interview developed by the writers.

Major Findings and Conclusions.—The science interested student is equal in ability to the science disinterested students; however, the science interested student performs higher on the average in science ability. The science interested student was more aware of the role of science in everyday life. The science interested student likes most fields of science, but has one which he likes best. The science disinterested student tended to natural history or curiosity generating areas in science of local immediate interest.

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CHASE, JOHN BRYANT, JR. A Project in the Cooperative Production of Instructional Guides for Teachers of Science. Ed.D., 1954, University of Virginia, Charlottesville.

Major Faculty Adviser.—Dr. Frank G. Lankford, Jr.

Problems.—(1) To discover the desires of selected teachers of science throughout the United States for instructional guides in science. (2) To produce a sample instructional guide in science, meeting the desires of the teachers selected. (3) To use the sample guide to help teachers produce cooperatively through classroom experimentation other instructional guides.

Prodecures.—State departments of education in 38 States suggested 324 teachers who might be interested in joining this project. Each of the 324 teachers was asked by questionnaire to recommend topics for which he would like to have instructional guides. To determine what teachers wanted in an instructional guide, 17 proposed items were listed, and teachers were asked to revise and supplement the list. One hundred and thirty-two teachers from 36 States responded.

To discover the desires of science teachers in a particular State (Virginia) for instructional guides, 736 teachers were asked by questionnaire to indicate at least three topics for which they would like to have guides. Three hundred and eighty-two Virginia teachers responded. The writer produced a sample instructional guide on *Microscopic Living Things in Relation to Human Activities.* The sample guide was mailed to participating teachers to use in teaching this topic, and they were asked to report their ideas for improvement of the guide. Superintendents and directors of instruction from 54 school divisions in Virginia suggested 129 teachers of high school science whom they thought would be qualified and interested in working with the writer to produce instructional guides. One hundred and one of these recommended teachers later expressed personally a willingness to help in the cooperative production of additional guides similar to the sample guide on *Microscopic Living Things in Relation to Human Activities.*

Major Findings and Conclusions.—The following guides were produced: (1) *The Earth's Weather and How It Affects Us,* (2) *Heredity and Evolution,* (3) *The Nature of Matter and Chemical Energy,* and (4) *The Nature and Use of Electricity.*

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CURTIS, CHARLOTTE. A Determination of Mathematical Terms in Secondary School Physics Textbooks. M.Ed., 1953, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problems.—To find how many mathematical

terms are used in the discussion of the various fundamental principles in physics and which principles require the most and which the fewest mathematical terms for their explanation.

Procedures.—The mathematical terms which appeared in five textbooks were tabulated. Those principles which appeared in at least three of the five textbooks were listed.

Major Findings and Conclusions.—To understand high school physics textbooks requires a knowledge of arithmetic, simple algebra, geometry, and fundamentals of trigonometry. More mathematics is required for the study of mechanics than any other topic in physics. Less mathematics is required in the study of atomic energy than in the other units. Most physics tests cover approximately the same material in essentially the same manner. Since mechanics is the most difficult part of physics from a mathematical standpoint, and since most physics courses undertake mechanics at the outset of the course, it is recommended that the order of presentation of material be rearranged so that the simpler principles of atomic theory be presented first and mechanics relegated to a later part of the course.

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DELOACH, WILL S. General Chemistry Textbook Prices, 1925–1951. 1953, Arkansas State Teachers College, Conway.

Problem.—To investigate the "real cost" of college general chemistry textbooks published in 1925–1951.

Procedures.—Through the study of periodicals and reference material, the list prices of general chemistry textbooks from 1925 to 1951 were compiled. The prices of the books were adjusted for variation in the purchasing value of the dollar.

Major Findings and Conclusions.—The "real cost" of college general chemistry textbooks rose during depression years, then declined, and in 1951 was at its lowest (except for one year).

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DELOACH, WILL S. Turnover of High School Chemistry Teachers, Alabama, 1942–1953. 1954, Arkansas State Teachers College, Conway.

Problem.—To determine the amount of turnover among high school chemistry teachers in those Alabama high schools that teach chemistry every year.

Procedures.—Data were obtained mainly by examination of the accreditation reports on file in the State Department of Education.

Major Findings and Conclusions.—A total of 218 persons taught chemistry in the 52 schools during 1942–1953. Ten taught all 12 years in the same school, and 100 taught only one year. The greatest turnover came during the first half of the period—1942–1947. In 1953–1954 there were 61 chemistry teachers in the 52 schools. Of these 61, 20 were in their first year and 10 had taught all 12 years in their present positions. Slightly over half of the 1953–1954 teachers had taught chemistry 5 consecutive years or longer in their present positions.

DOUGLASS, MALCOLM PAUL. Interrelationships Between Man and the Natural Environment for Use in the Geographic Strand of the Social Studies Curriculum. Ed.D., 1954, Stanford University, Stanford, California.

Major Faculty Adviser.—Dr. Paul R. Hanna.

Problem.—To analyze selected literature in human geography for interrelationships between man and the natural environment.

Procedures.—The investigation involved four steps: (1) Establishment of criteria defining the nature of man's interrelationships with his environment. (2) Selecting primary sources on human geography. (3) Identifying and recording statements of interrelationships as they appeared in the literature. (4) Synthesizing the statements into a discrete list of interrelationships.

Major Findings and Conclusions.—The investigator derived 824 discrete statements of interrelationships between man and his environment. These were organized under logical subheadings.

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DROULLARD, CLAYTON ARTHUR. Pre-service and In-service Science Education of Iowa Secondary School Science Teachers. Ed.D., 1954, University of Colorado, Boulder.

Major Faculty Adviser.—Dr. Harold M. Anderson.

Problems.—(1) To reveal the science subject-matter backgrounds of Iowa secondary school science teachers, (2) to compare teaching assignments among teachers of biology, chemistry, general science, and physics, and (3) to obtain information on the in-service education of Iowa secondary school science teachers.

Procedures.—A questionnaire was constructed, validated by a jury, and mailed to a stratified random sample of Iowa secondary school science teachers. There were 1,418 secondary school science teachers in Iowa in 1953–54, and the instrument was sent to 400. Seventy-two per cent of the 400 responded.

Major Findings and Conclusions.—Iowa secondary school science teachers had more training in chemistry than physics but taught more physics than chemistry. General science was taught by 56.2 per cent of the science teachers, biology by 55.9 per cent, physics by 36.4 per cent, and chemistry by 21.3 per cent. Biology teachers had a mean of 21.7 semester hours of biology. Fifty and eight-tenths per cent of the science teachers taking undergraduate work in Iowa were graduates of non-public institutions of Iowa. Master's degrees were held by 22 per cent of the science teachers; 93 per cent had at least a bachelor's degree. Only 17 of 281 science teachers reported in-service education programs in their schools. Ninety-three of 263 science teachers indicated no special activity during the summer of 1953 to increase science teaching competence.

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EBLEN, WILLIAM ROBERT. The Audio-Visual Program at Kingswood School, West Hartford,

Connecticut. M.S., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Eva L. Gordon.

Problem.—To develop an audio-visual program.

Procedures.—The study was based on library research and the study of audio-visual aids.

Major Findings and Conclusions.—Some of the features of the Audio-Visual Program were: (1) schedule provided for teachers to sign for the use of the visual aids room each week, (2) monthly meetings for all interested teachers to inform them of films available, (3) an audio-visual file for the school library that will make the librarian solely responsible for the mechanics of the program, and (4) an audio-visual room with complete facilities for showing sound and silent 16 mm. films, kodachrome slides, lantern and opaque slides, and filmstrips.

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EISS, ALBERT F. A Determination of the Relative Importance of Knowledges of Science to the Duties of Hotel Managers. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Professor Cyrus W. Barnes.

Problem.—To determine the relative importance of knowledges of science to the duties of hotel managers.

Procedures.—A questionnaire was prepared in cooperation with experts in the hotel industry, and it was mailed or used as a basis for personal interviews until replies from 75 New York State hotel managers systematically selected from each of three groups were received. The groups were: small hotels (0–100 rooms), intermediate hotels (101–250 rooms) and large hotels (more than 250 rooms). The relative value of each duty that involved knowledges of science was determined.

Major Findings and Conclusions.—It is concluded that knowledges of science are important to managers of small hotels to a significantly greater extent than to managers of intermediate or large hotels. Most of the important knowledges are related to health and safety and may be classified under physics or biochemistry. It is evident that these subjects should receive primary consideration in a science program in training hotel managers.

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FLANNIGAN, NORMAN ANTHONY. A Study of High School Courses in Grades 9–12 Designed for General Education. Ph.D., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Eva L. Gordon.

Problems.—The purposes of this investigation are (1) to give a current picture of the status of general education science in the public high schools of the United States, grades 9–12, through study of (a) the place of general education science in the curricula of sample schools, (b) the methods used in teaching such courses, (c) the methods of selection of content, and (d) an evaluation of the general education science objectives of the schools in which such courses are taught and (2) to show how these general education science courses compare in the above areas with the usual conventional science courses: general science, general biology, elementary physics, and elementaıy chemistry.

Procedures.—A random sample of 800 public high schools was used. Of the 800 schools, 117 returned completed checklists in which 216 courses were reported representing 47 different types of courses.

Major Findings and Conclusions.—On the basis of information supplied by the 117 schools via the checklists, the following conclusions have been drawn: (1) General education science courses, especially those used to replace the conventional courses in chemistry and physics, are increasing in the public high schools. This is based on the starting dates of courses mentioned and from change in enrollment in the courses. (2) The great majority of these courses are developed for the junior and senior years. This would seem to indicate that many schools are fairly well satisfied with freshman general science and sophomore general biology but are trying to form a four-year science sequence in terms of general education. However, a considerable number of these courses enroll sophomores, indicating that general biology as a sophomore subject has not been nationally accepted. (3) Laboratory work in included in three of every four of the general education courses studied. In seven of every ten of these lab courses, the students are required to work individually or in pairs. (4) Checklist data show that more than six of every ten general education science courses are accepted by colleges for entrance credit. (5) Principals prefer men teachers to women for their general education science courses in a ratio of about seven to three. (6) General education science courses are not considered courses for the slow learner. Only about 3 per cent of the sample courses are used for this purpose. (7) The subject-matter survey course is still the most popular means of presenting general education science material in the secondary school. (8) No general agreement is indicated as to specific topics to be included in general education science courses due in part to differences in environment, type of student served, and geographical location.

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FRANKS, CLEVELAND JAMES. The Organization, Installation, Implementation, and Administration of a Course in Physical Science Designed for General Education at the Morgan State College. Ed.D., 1953, Teachers College, Columbia University, New York City.

Major Faculty Adviser.—Dr. Hubert M. Evans.

Problems.—(1) What are the types of situations, problems, and interests in science most likely to challenge the individual in a democratic society, and how are these related to our institutions and ways of living? (2) What kinds of abilities and traits do we seek to develop in our science students as we help them to prepare for effective participation in our society?

Procedures.—A two-year experimental science program was developed from student's real problems and interests. This course was offered to four classes for two years and compared with the traditional physical science survey course which was offered simultaneously to four classes. Both courses were evaluated.

Major Findings and Conclusions.—For many non-science majors the specialized courses provided in the various science departments are not satisfactory. The "block-and-gap" approach is better than the superficial survey or diluted orthodox science course. Student suggestions and criticisms can be of value in locating weaknesses in a program designed for general education science. The general education science program should be flexible enough to allow the teacher to capitalize on the special interests and capacities of pupils.

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FRASIER, JAMES EDWIN. A Supervisory Program for the Improvement of Instruction of Selected Areas of Junior High School Science. Ed.D., 1954, Colorado State College of Education, Greeley.

Major Faculty Adviser.—Dr. Donald G. Decker.

Problem.—The basic problem was to determine how much measurable difference could be made in the pupils' ability to use the scientific method of problem solving, to develop and maintain scientific attitudes, and to develop power in the use of scientific vocabulary.

Procedures.—The study was a controlled experiment with 1,000 seventh grade pupils. A pre-test was given to an experimental and control group; supervision was given to the experimental group only; and a post-test was administered.

Major Findings and Conclusions.—Seventh grade pupils do not naturally have scientific attitudes nor do they know how to apply the scientific method. When these things are specifically taught for, as with the experimental group, statistically significant progress is made. This is especially true of the development and maintenance of scientific attitudes. It is also interesting to note that the experimental pupils, whose instruction emphasized problem solving and scientific attitudes, did equally as well as the control group in the accumulation of traditional subject-matter knowledge.

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GEGA, PETER CHRISTOPHER. College Courses in Elementary-School Science and Their Relation to Teaching Problems. Ed.D., 1955, University of Southern California, Los Angeles.

Major Faculty Adviser.—Dr. Raymond C. Perry.

Problem.—To determine the relationship between reported problems in teaching elementary-school science and contemporary California teacher-training institutions courses in elementary-school science.

Procedures.—A check list of problems in the teaching of science in the elementary school was compiled through a study of the literature and data from 52 supervisors. California teacher-training institution instructors of elementary-school science were interviewed about the courses.

Major Findings and Conclusions.—(1) The most frequently reported science teaching problems, in descending order, were those which involved (a) materials and resources, (b) teacher skills, techniques and security, (c) organization of instruction, (d) human relations, administration, and supervision, and (e) objectives and evaluation. (2) Ten teacher-training institutions offered one course in elementary science, five offered two courses, three offered three courses, and one offered twenty-two (quarter semester) courses. (3) Eight institutions required a course in elementary science for elementary education students; twelve did not. (4) Nine of the basic elementary-science courses were taught with an integrated approach to content and method, seven emphasized method, and four were organized for content mastery.

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GEORGISON, CLIFFORD G. A Study in Science Education. 1954, San Francisco State College, San Francisco, California.

Major Faculty Adviser.—Dr. Robert J. Stollberg.

Problem.—To determine the preparation needed for teachers to effectively teach science.

Procedures.—A questionnaire was sent to the teachers in six communities in California. Eighty questionnaires provided the data for the study.

Major Findings and Conclusions.—The teachers indicated they were prepared for field trips, demonstrations, experiments, and the student teaching was adequate. However, in the following areas they needed additional assistance: maintenance of science equipment, directing pupil projects, and selecting and ordering science materials. They indicated that more observation of experienced high school teachers at work would have been helpful.

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GIFFORD, ROBERT WALTER. A Description of Certain Changes Accompanying Practice Teaching and Concomitant Experience. Ed.D., 1954, Teachers College, Columbia University, New York City.

Major Faculty Adviser.—Dr. F. L. Fitzpatrick.

Problem.—To study certain changes that take place in student teachers during practice teaching.

Procedures.—A study was made of 20 practice teachers of the Department of the Teaching of Science, Teachers College, Columbia University, in the Spring Session of 1949. The evidence was gathered through written questionnaires, individual conferences, weekly report forms, and classroom observations of their teaching. The results of the diagnostic speech examination, comprehensive science examination, and the number of hours spent in practice teaching experience were also available.

Major Findings and Conclusions.—Even though the evidence was not conclusive, it seemed that all practice teachers made some changes in a positive direction during the semester of the study. There

were more changes from originally weak positions relative to the characteristics, than from original positions which seemed sound. The number of changes in a negative direction were very few. There were certain characteristics about which insufficient evidence was available to arrive at an evaluation of change.

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GIOVANNANGELI, ARTHUR J. The Selection, Development, and Objective Evaluation of Concepts in Alcohol Education as an Aid to Curriculum Construction. Ed.D., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problems.—(1) To determine the accuracy of statements representing certain concepts concerning the use and effects of alcoholic beverages which are important to general education. (2) To produce a reliable source of concepts about the use and effects of alcohol which can be used for study and reference by teachers, curriculum-construction groups, and textbook writers.

Procedures.—(1) Review of the literature and research on the alcohol concepts of the last ten years which are pertinent to the study. (2) Refresher course at the Yale School of Alcohol Studies. (3) Selection of concepts. (4) Translating the concepts for clarity and better understanding. (5) Trial-run. (6) Checklist Rating Scales. (7) Selection of jury members to determine the accuracy of the concepts. (8) Selection of jury members to evaluate the concepts in terms of their importance for general education.

Major Findings and Conclusions.—Out of a total of 190 concepts only 18 were judged true by all the jury members, and one was judged false by all. As indicated by the jurors' responses, 139 concepts should be taught as "true," 13 as "false," and 21 as "debatable." Out of 93 concepts evaluated in terms of their importance in general education, 29 were rated as being highly important, 48 as being important, and 16 as being of little importance.

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GLADIEUX, ROLLAND J. A Study of the Extra-Class Science Activity in the Public Secondary Schools of New York State Exclusive of New York City. Ed.D., 1954, University of Buffalo, Buffalo, New York.

Major Faculty Adviser.—Dr. Adelle H. Land.

Problem.—To determine the present status of extra-class science activity in the public secondary schools of New York State: its nature, its extent, its outcomes, and the degree to which this activity is compatible with the philosophy of modern education.

Procedures.—The general method used in the study was that of the normative survey. Four questionnaires were prepared and used concerning (1) school science clubs, (2) regional science congresses, (3) the Science Talent Search, and (4) the New York State Science Congress. The first was sent to the science teachers in 160 schools on a random sampling basis. The percentage of returns was 97.5. The second questionnaire was sent to the directors of the regional science congresses of the State, and the third was sent to the science departments of 18 schools which had achieved an arbitrarily determined high degree of success in the annual Science Talent Search, while the fourth questionnaire was directed to the 27 student contestants of the first annual New York State Science Congress. The returns were 100 per cent in these three instances.

Major Findings and Conclusions.—Various types of science contests have been developed in recent years to offer incentive and reward for outstanding student achievement in science. They are sponsored and conducted in some instances on a nation-wide basis by industry, by professional scientific societies, and by science-teacher organizations. The most important single factor involved in the success of a science club or other extra-class science activity appears to be the availability and willingness of the science teacher to assume the responsibility of sponsorship. A factor, however, which reduces the effectiveness of science teachers in directing such activities is simply that they are assigned too many non-teaching non-science duties.

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GUSTAFSON, JOHN ALFRED. A Study of Those Extra-Curricular Activities Which Contribute to Nature and Conservation Education in Certain Liberal Arts Colleges. Ph.D., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Eva L. Gordon.

Problem.—To point out how nature and conservation education may be furthered through extra-curricular activities. It was undertaken with the idea that a plan might be devised which would be applicable to many liberal arts colleges and thus be a means of extending conservation education.

Procedures.—(1) Historical research into the background of the extra-curricular outdoor programs at Dartmouth College and Bowdoin College. (2) Questionnaires were sent to sample opinion of alumni, faculty, and undergraduates regarding the worthwhileness of these extra-curricular programs. (3) An inquiry form was submitted to a sample of 150 liberal arts colleges across the country to find out the status of such extra-curricular programs at this time. College catalogs were also surveyed for useful information.

Major Findings and Conclusions.—Extra-curricular activities which combine recreation and nature study in an informal way are far superior media by which proper conservation attitudes and ethics can be developed than are the traditional methods of classroom and laboratory instruction.

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HAMER, LOIS LORENE. Developing a First Grade Elementary Science Program in a Rural Community. M.A., 1954, Ball State Teachers College, Muncie, Indiana.

Major Faculty Adviser.—Dr. Robert H. Cooper.

Problem.—To plan, develop, and introduce an elementary science program in the first grade of a rural community school.

Procedures.—Elementary science textbooks and courses of study were reviewed. These served as aids in constructing 10 units prior to the opening of school. Units were augmented on the basis of pupil interest evidenced during the school year. Individual contributions to the science program were recorded and classified daily. Units were ranked according to amount of interest.

Major Findings and Conclusions.—Additional units (seeds, insects, gardening, birds, and conservation) were prepared because of increased pupil interest and contributions. Total time devoted to the understanding of science increased during the spring months. The science program aided in the development of skills in language arts, arithmetic, and art.

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HARLOW, JAMES GINDLING. An Inventory of Instructors' Judgments Concerning Programs in General Education Science. Ph.D., 1954, University of Chicago, Chicago, Illinois.

Major Faculty Adviser.—Dr. Norman Burns.

Problem.—To develop instruments for use in locating and describing the opinions of instructors about college programs in general education science and to apply the instruments to determine the opinions of a selected group of instructors.

Procedures.—The basic investigative device was the questionnaire. The instructors selected were from twenty-three higher institutions other than municipal junior colleges in the State of Oklahoma.

Major Findings and Conclusions.—Checklists were developed as follows: aims of general education programs in science, characteristics of the instructor, characteristics of the curriculum, characteristics of the laboratory, and the characteristics of the library.

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HAUPT, WALTER N. The Historical Background of Science Teaching in Junior High Schools Since 1920. M.Ed., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problem.—To trace the development of secondary school science, especially in grades 7, 8, and 9, between 1900 and 1954.

Procedures.—The changes in theories and practices in junior high school science were traced through comparison of (1) objectives listed in studies made in 1900, 1924, 1927, 1931, 1941, 1942, and 1952 and (2) teaching methods used in 1900 and 1952.

Major Findings and Conclusions.—There is less agreement as to methods and purposes of science in education today than previously. The trend is toward exploration, differentiation, socialization, and articulation, especially in junior high schools. There is more individual and social integration today with less emphasis on college or vocational preparation.

HOCH, LOREN L. The Use of Sponsored Films in Teaching Biology. M.A., 1954, Ball State Teachers College, Muncie, Indiana.

Major Faculty Adviser.—Dr. Donald E. Miller.

Problem.—To survey biology teachers in the State of Indiana in order to discover their evaluation of free-loan films and those from regular educational producers.

Procedures.—A stratified random sampling of all public and parochial high schools in Indiana was made. Questionnaires were sent to 200 high schools in the State.

Major Findings and Conclusions.—Smaller high schools make greater use of free-loan films than larger high schools. Fifty-four per cent of the teachers thought that free-loan films better suited their needs. Sponsors are doing a good job in producing films for biology classroom use.

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HUCKER, DONALD ALAN. The CK-722 Transistor. M.S., 1954, Northern Illinois State Teachers College, DeKalb.

Major Faculty Adviser.—Dr. W. B. Miner.

Problem.—To prepare a unit to teach the history and physics of the transistor.

Procedures.—This study is divided into four parts: the first part is on the history of the transistor; the second part describes in detail the physics of the transistor; and the third section describes an experiment that will demonstrate to the student the difference in the operating characteristics between the CK-722 transistor and a triode vacuum tube. A concluding section is a review of the main points of each section in the body of the study.

Major Findings and Conclusions.—It was found that the fundamentals of transistor operation can be condensed into a unit that can be presented to a class that has some knowledge of electronics.

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HURLBUT, ZYLPHA DORLESKA. Ability to Select Scientific Hypotheses. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Dr. J. Darrell Barnard.

Problems.—The purposes of this study were (1) to determine some of the factors which influenced a certain group of college freshmen in selecting scientific hypotheses and (2) to find the relationship between these factors and other pertinent information regarding these students.

Procedures.—Copies of the 15 problem-situations were presented to 258 students enrolled in college freshmen science classes in four colleges and universities. These students suggested 1,141 different hypotheses. Analysis of these hypotheses revealed five levels of thinking. A selection of representative hypotheses was presented to 56 first semester college freshmen enrolled in Anderson College. The written responses of these freshmen were analyzed to determine factors which had influenced their selection of hypotheses.

Major Findings and Conclusions.—These stu-

dents' ability to select hypotheses was represented by their respective points of deviation in hypotheses ranking. Calculation of Fisher T's revealed that of the 28 relationships found only seven were significant.

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JOHNSON, LLOYD KENNETH. A Study of Achievement in Physics at the Secondary School and Junior College Levels with Implications for Grade Placement of Concepts. Ph.D., 1954, University of Nebraska, Lincoln.

Major Faculty Adviser.—Dr. Harold E. Wise.

Problem.—To determine the school level (junior high school, senior high school, or junior college) at which understandings of certain principles of physics sufficient to meet the needs of general education are being developed.

Procedures.—The study was based on principles of sound, static electricity, and magnetism which are presented in approximately the same manner in selected textbooks for ninth grade general science, high school physics, and college physical science survey courses. A test was constructed to measure understanding of these principles. It was refined on the basis of item analysis following its administration to trial groups and in final form was found to be sufficiently valid and reliable for group comparisons. This test and an intelligence test were administered to 845 students in 31 schools. Eleven classes of general science, twelve classes of physics, and eight classes of physical science survey were included. Comparisons were made by the methods of analysis of variance and analysis of covariance with the effect of intelligence controlled. Group mean scores were used as the sampling units.

Major Findings and Conclusions.—On the basis of evidence revealed by this study, there appears to be considerable unnecessary duplication in the development of understanding of principles of sound, static electricity, and magnetism between ninth grade general science, high school physics, and physical science survey courses at the college level. Insofar as the development of understandings of the principles of sound, static electricity, and magnetism used in this investigation is concerned: (1) Students who have completed ninth grade general science can profit by a course in high school physics. However, students who have completed both ninth grade general science and high school physics probably cannot, under present instructional practices, profit by a physical science survey course at the college level. (2) Students who have completed ninth grade general science probably cannot, under present instructional practices, profit by a physical science survey course at the college level.

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KASLING, ROBERT WILLIAM. Cooperating With Nature—A Reference Book of the Conservation of Natural Resources Prepared for the Junior High School Level. Ed.D., 1954, New York University, New York City.

Major Faculty Adviser.—Dr. J. Darrell Barnard.

Problem.—To prepare a reference book covering the general field of the conservation of natural resources for use by junior high school students.

Procedures.—Four subsidiaries were constructed to investigate the problem. The first was the determination of inadequacies of conservation material in science and social studies books written for junior high school students. This was done to provide the basis for strengthening the content of this study. The second subsidiary involved the selection of sources of conservation material. The third was an analysis of the sources and selection of appropriate materials. The final subsidiary was the organization of the material into book form.

Major Findings and Conclusions.—A list of motion picture films was compiled on the basis of the author's personal review of films produced by all Federal agencies concerned with conservation. The organization of the material into book form was constructed upon the fundamental findings of the investigation.

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KING, ALBERT WELLS. Directions for the Locating and Preserving of Flora and Fauna to Be Found in the Vicinity of Cincinnati Country Day School, Cincinnati, Ohio. M.Ed., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Philip G. Johnson.

Problem.—To develop plans for finding and preserving examples of most of the common classes of plants and animals which live within a few miles of Cincinnati Country Day School just outside of Cincinnati, Ohio.

Procedures.—This study is based on library research and personal experience in the locating, culturing, and preserving of specimens.

Major Findings and Conclusions.—The essay is a source of collection, culture, and preservation methods for representatives of all common phyla and classes of plants and animals which can be found in temperate inland environments in the United States. An appendix gives lists and maps locating by name the trees and shrubs on Cincinnati Country Day School property.

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KRUGLAK, HAYM. How Many Partners in the General Physics Laboratory? 1954, Western Michigan College, Kalamazoo.

Problem.—To determine the degree to which laboratory achievement is a function of the number of partners.

Procedures.—This is an experimental study using a sampling of students and instructors. The control groups of students worked singly, in pairs, or in quartets. Achievements of all groups were compared.

Major Findings and Conclusions.—(1) Laboratory achievement in general physics, as defined by mean scores on multiple choice and performance tests, is independent of the number of students working on an experiment (up to four) (2) Laboratory achievement, as defined by mean

scores on multiple choice and performance tests, is not measurably influenced by the laboratory instructor. (3) Students working in quartets earn better average marks on laboratory reports written in the laboratory than students working singly or in pairs. (4) Laboratory grades based primarily on written laboratory reports vary significantly from instructor to instructor. (5) Scholastic aptitude tests are poor or unreliable predictors of laboratory achievement in physics. Academic standing is a fair predictor of laboratory grades.

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KRUGLAK, HAYM. Paper-pencil Analogs of Laboratory Performance Tests. 1954, University of Minnesota, Minneapolis.

Problem.—To what extent is the ability to solve a laboratory problem on paper related to the ability to solve the same problem using apparatus and materials?

Procedures.—Three forms of a laboratory test in electricity were constructed and administered to pre-medical students and engineering students at the University of Minnesota. The items on the essay and multiple choice forms were made as analogous as possible to the corresponding performance tests. Extensive use was made of photographic technique to simulate the actual laboratory situations on paper.

Major Findings and Conclusions.—There was, in general, a low degree of relationship between the performance and other forms of the test.

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LAMBERT, FRANCES. Results of Demonstrating and Testing of the Physical Science Principle: Any Body of Liquid Free to Take Its Own Position Will Seek a Position in Which All Surfaces Lie in the Same Plane. M.Ed., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problem.—To determine the grade placement of the concept that liquids seek their own levels.

Procedures.—Classes of both fourth and sixth grade pupils were used in this study. After a pretest was administered one half of the group which became the control group was sent out of the room to spend the next fifteen minutes in nonscientific reading. The other half of the group watched a brief lecture demonstration on the concept that liquids seek their own levels. This demonstration lasted about fifteen minutes. Then both the control group and the group which had seen the demonstration took the identical test again.

Major Findings and Conclusions.—There were no definite conclusions. Since the author's work reached only about 200 pupils, he recommended that the experiment be repeated with many more pupils.

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LAMPKIN, RICHARD H. Validity of Test Items That Involve Finding a Pattern in Data. 1954, State University College for Teachers, Buffalo, New York.

Problem.—To study the validity of certain test items that are used to measure the ability to find a pattern in data.

Procedures.—Twenty-six tests were studied which had 409 number series items. The validity of this particular type of item is discussed.

Major Findings and Conclusions.—It is concluded that number series items are not valid and that further use of them is questionable.

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LEWIS, JUNE E. An Investigation of the Effectiveness of the Science Sequence in Certain Teachers Colleges. Ed.D., 1953, Harvard University, Cambridge, Massachusetts.

Major Faculty Adviser.—Dr. Fletcher G. Watson.

Problem.—To investigate the effectiveness of the required teachers college science sequence in the development of certain problem-solving abilities. The term "effectiveness" is interpreted as meaning significant changes in student behavior as measured by an objective test.

Procedures.—Pre-test and post-test of 237 students from 8 teachers colleges in northeastern States were given.

Major Findings and Conclusions.—(1) Statistically significant increase in problem-solving abilities as measured by the test occurred at the termination of the science sequences in the 8 colleges. (2) Score gains are not affected significantly by variations in the numbers of years of pre-college science training. (3) The 8 college groups made equivalent gains in factual knowledge, but different gains in problem-solving abilities.

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MACCURDY, ROBERT DOUGLAS. Characteristics of Superior Science Students and Some Factors That Were Found in Their Background. Ed.D., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problem.—To identify significant characteristics and some background factors in the lives of superior science students.

Procedures.—An inquiry form was developed from items suggested by research, advisers, students, scientists, and the author. Several juries edited the inquiry form, changing and removing items. The form was sent to 600 winners or honorable mention winners of the Science Talent Search for 1952 and 1953. Eighty-five per cent of the forms were completed and returned. The responses were analyzed. Also the responses from a group of generalists were contrasted with those of the test group.

Major Findings and Conclusions.—The personality of superior science pupils includes a strong curiosity, control of their own tempers, persistence, and appreciation of complex things. Their attitudes and opinions involve being social minded, materialistic, not being superstitious, suspended judgment and constantly attempting to separate judgment from prejudice. Their interests embrace reading science, studying, taking nature

walks, playing chess, workshop activities, photography, inventing things, and building radio and hi-fi sets. In high school they were scholarly, scientific, earned a higher academic average, never failed a course, members of honor societies, gave lecture demonstrations, worked on school publications, members of scientific societies, enjoyed mathematics, and entered projects for competition. Their families were usually financially secure, well educated, respected science, and lived in large cities. Their associates included scientists and friends interested in science. Their science teacher had a great influence on their science interests.

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MCPHERSON, MARGARET JULIA. A Study of High School Science Clubs. M.A., 1955, University of Texas, Austin.

Major Faculty Adviser.—Dr. I. I. Nelson.

Problem.—To study the organization and activities of science clubs in secondary schools and their values to science club members, to the program of science education, and to the future advancement of science.

Procedures.—Study of literature bearing on science clubs and appearing in recent (since 1940) periodicals, books on the teaching of science, also bulletins, leaflets, and booklets published by industry and governmental agencies. Questionnaire returns from selected Texas high schools.

Major Findings and Conclusions.—(1) The absence of science clubs in a high school does not necessarily indicate lack of interest in such activities. (2) The four main high school sciences—general science, biology, chemistry, and physics—furnish the basis for practically all of the science clubs. (3) Highly specialized science clubs are relatively few in number. (4) Values derived from high school science clubs seem to indicate the need for broadening the scope of this type of science activity.

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MCWHIRTER, NOLAN. The Status of General Biology in the General Education Program of Colleges and Universities in Arizona, Colorado, Kansas, Nebraska, New Mexico, Oklahoma, and Texas. M.A., 1953, Colorado State College of Education, Greeley.

Major Faculty Adviser.—Dr. Donald G. Decker.

Problem.—To find the status in course content and methods in general biology in the general education programs of colleges and universities in seven southwestern States.

Procedures.—The data for this study was obtained by use of a questionnaire. A total of 70 of 119 institutions, 58.82 per cent of the four-year institutions in the seven States, took part in the study. Some declined because general biology was not included in the curriculum of their schools.

Major Findings and Conclusions.—General biology is a part of the general education program in 84.69 per cent of the institutions represented in the seven States represented in this study. General biology is included as a part of the science requirement for general education in almost all the institutions covered in the survey. Laboratory is a part of the general biology course in 80.64 per cent of the institutions responding to the questionnaire. The general biology course is a one-semester course for four credit hours (semester hours) in the majority of the institutions throughout the seven southwestern States. Of the instructors in the institutions represented by this study, 82.85 per cent are men. A total of 41.42 per cent hold the rank of professor or its equivalent. Eighteen different texts were used in the 53 institutions listing their texts. No one text could be listed as being the one used by a majority of the institutions.

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MASON, JOHN M., and ANGELL, GEORGE W. The Improvement of General Education Courses in College Biology. 1954, Michigan State College, East Lansing.

Problem.—To obtain information relative to the value of the discussion method in teaching biological science in college.

Procedures.—The subjects were 93 students enrolled in five laboratory sections in the first term of a three-term course in biological science at Michigan State College, winter term, 1949. The teaching variable was a 20-minute discussion carried on with the students in certain laboratory sections during the regular laboratory period. The instructor assumed the responsibility for directing the discussion period and a definite attempt was made to establish rapport with the students and to maintain situations in which they would feel free to express themselves.

Major Findings and Conclusions.—Students in the laboratory periods in which the discussion activity was carried on did slightly better on instructor-prepared tests designed to measure factual information than did students in the control group in which the discussion activity was not a part of the instructional program. Students participating in the discussion activity, as indicated by their responses to an unsigned questionnaire, felt that the discussion period not only provided experiences which were helpful with respect to such objectives as acquisition of facts and ability to solve problems, but also opportunities for growth in some of the more general aims of education.

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MASON, JOHN M., and WARRINGTON, WILLARD G. An Experiment in Using Current Scientific Articles in Classroom Teaching. 1954, Michigan State College, East Lansing.

Problems.—To design and to carry through a discussion technique which would give students training in the critical evaluation of current scientific articles as one means toward the development of the ability to think scientifically and to evaluate this technique.

Procedures.—This study compared two methods of teaching students in a one-hour recitation period with respect to acquisition of the ability to think

scientifically. One method, employed with the experimental group, stressed the analysis and evaluation of current scientific articles as a means toward the attainment of this objective and the other method, using with the control group, was concerned mainly with location of student difficulties and the acquisition of factual information.

Major Findings and Conclusions.—The main findings and tentative conclusions of this study are: (1) The technique designed to give students training in the analysis and critical evaluation of current scientific articles as one means toward the development of the ability to think scientifically was no more effective with respect to student acquisition of this ability, as indicated by their scores on the instruments used, than the method employed in teaching the students in the control group. However, the students who had the training in the critical analysis and evaluation of current scientific articles indicated by their reaction to a free response questionnaire that they felt that they had become more scientific in their thinking due to this training. (2) The mean of the students in the control group was somewhat higher for the term-end examination than the mean of the students in the experimental group. In view of this finding, it appears that the readings used for analysis and evaluation should be directly related to the subject matter of the course. This finding together with other observations indicated that while seven hours apparently was not enough time to produce any statistical change in student behavior with respect to critical thinking the same amount of time was possibly beneficial in regards to the acquisition of subject-matter content.

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MECAY, LEROY E. Heredity in Non-Technical Magazines as a Basis for Genetics in General Education of Teachers. Ed.D., 1954, University of Missouri, Columbia.

Major Faculty Adviser.—Dr. Ralph K. Watkins.

Problem.—To determine the extent to which a knowledge of genetics is needed by the layman in order to read with comprehension, understanding and appreciation the articles on the subject which appear in the non-technical periodicals having the greatest circulation.

Procedures.—The documentary frequency type of the normative survey was the method of research used in this study. The complete issues of 12 non-technical magazines published for the period 1949–1953 were the sources of data.

Major Findings and Conclusions.—The significance of the 602 articles obtained from the 1,520 issues lies in the fact that a highly specialized subject, such as genetics, appeals to and is being made available to the general reader. Two out of every four articles presenting a genetic topic pertained to animal genetics, while one article out of every four pertained to either human or plant genetics. The vocabulary burden of words and phrases needed to read the 602 articles was relatively small. A knowledge of at least 22 of the basic principles of genetics is needed if the general reader is to comprehend the context of all the genetic articles collected in this study. In every article, a knowledge of the principles and hypotheses of genetics is assumed by the writer of the article.

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MORTON, JAMES OTIS. Science Interests of Intermediate Grade Children. M.A., 1954, University of Utah, Salt Lake City.

Major Faculty Adviser.—Dr. Dasil A. Smith.

Problem.—To determine the science interests of intermediate grade children in the Salt Lake City Public Schools during the academic year 1953–1954.

Procedures.—Four interest finding techniques were used to determine science interests: (1) Science interests through textbook topic selection, (2) science interests through the selection of science pamphlets, (3) science interests through personal interview, and (4) science interests through a check list questionnaire.

Major Findings and Conclusions.—A comparison of the results of the four interest finding techniques indicated a lack of agreement as to exact rank of the interest areas. All methods indicated a strong interest in ancient animals and plants. Interest was also indicated in the sun and the planets, constellations and gallaxies, magnetism and electricity, and the earth and its surface. Machines and how they work was not of great interest to the children as indicated by this study.

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NAVARRA, JOHN GABRIEL. The Development of Scientific Concepts in Childhood: A Study of a Young Child's Interaction with the Physical Phenomena of His Environment. Ed.D., 1954, Teachers College, Columbia University, New York City.

Major Faculty Adviser.—Dr. G. S. Craig.

Problem.—The specific question of the study was "What is involved in an actual situation in which a child learns about his physical environment?"

Procedures.—The investigator studied his own son for about two years. Essentially, the collection of the data was based upon continuous direct observations of the child. The child's mother was involved as collaborator on all facets of the problem.

Major Findings and Conclusions.—The process in which the child engaged and the attendant pattern of behavior which evolved were not wholly self-initiated. Rather there seemed to be certain determinants which facilitated his ability to operate in this way. One of the prime determinants recognized in this study is the mitigating influence of the adults with whom the child came in contact.

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NEWSOM, CARL RAY. General Education Science in Methodist-Related Junior and Senior Colleges. Ph.D., 1953, George Peabody College for teachers, Nashville, Tennessee.

Major Faculty Adviser.—Dr. C. L. Hall and Dr. H. A. Webb.

Problem.—To determine the present status of general education science courses in Methodist-related junior colleges and senior colleges.

Procedures.—A search was made of the literature for related studies. Data were collected through questionnaires, personal correspondence, and school visitation. College catalogues and textbooks were analyzed.

Major Findings and Conclusions.—Most schools in the study offer general education courses which were recommended for non-science majors. Forty-seven per cent of the courses were two semesters and 36 per cent were one semester. The classes were usually very large (45 students). The content consisted primarily of physics. Thirty-eight per cent of the instructors have a Ph.D. degree. Few persons were employed to teach only general education science courses.

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NIERI, JEANIE. Using Science to Teach Reading in the First Grade. M.A., 1954, San Jose State College, San Jose, California.

Major Faculty Adviser.—Dr. Matthew Vessel.

Problems.—It was the purpose of this study: (1) to review basic word studies to determine possibilities of using science vocabulary in a first reader, (2) to review the more commonly-used first reader textbooks and summarize types of stories incorporated within them, (3) to write a basic developmental reader based on science as it related to the elementary school program following the broad-area curriculum, and (4) to write a sample teacher's guide emphasizing the study of some particular topic.

Procedures.—Basic word studies were reviewed and compared with each other in order to determine the apparent similarity or dissimilarity. First-grade readers were reviewed, and the types of stories noted in order to determine the variety and quality of subject matter used. An attempt was made to write stories based on science, including a sequential word study list. A teacher's guide was written.

Major Findings and Conclusions.—Children are capable of thinking about those subjects which make a difference to them and their life. As a child is led to think in his reading activities, he learns that reading is a tool. First-grade children must be given content material which challenges their thinking and insatiable curiosity. Children are entitled to learning materials which are suitable to their thinking capacity. It was proven by the writer that a first-reader can follow a sequential word study list—and still be based on facts (science), rather than fancy.

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OSBORNE, ETHELMAY. A Proposed Course of Study for Out-of-Door Science in the Eleventh and Twelfth Grades. M.S., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Eva L. Gordon.

Problem.—To develop a course of study for an "Out-of-Door Science" course.

Procedures.—Through an analysis of courses of study in science and other related material, a course of study was developed.

Major Findings and Conclusions.—The content of the course is divided into three large sections: (1) the study of the environment, (2) some principles of conservation, and (3) some current problems in conservation. The purpose of the first section is to get acquainted with the habitat areas. Then the principles of conservation and setting up activities to illustrate these facts are considered. The last three weeks is on the history of conservation, a few organizations active in conservation, and consideration of some current problems in conservation.

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PILTZ, ALBERT. An Investigation of Teacher-Recognized Difficulties Encountered in the Teaching of Science in the Eelementary Schools of Florida. Ed.D., 1954, University of Florida, Gainesville.

Major Faculty Adviser—Dr. N. E. Bingham.

Problem.—To determine the factors that, in the opinion of the classroom teachers, handicap the teaching of science in the elementary school.

Procedures.—The study was based on: (1) a survey questionnaire of a 10 per cent stratified random sample of all Florida teachers, (2) an interview of a limited sample of these teachers, and (3) observations of certain teaching situations.

Major Findings and Conclusions.—In the nine categories of difficulties, there was general agreement among all of the respondees that "physical facilities" was the category of greatest difficulty. The majority of teachers were weak in the methodology of science teaching. Lack of time was consistently mentioned as a great barrier to science teaching. The author concludes that the mention of time is a rationalization for either lack of "know-how" or lack of conviction of what is important in the curriculum. Emphases on reading and the language arts took priority over all the curricular offerings in the school program, including science. The most frequently used method of teaching science was to have children read science books. Nearly 75 per cent of the teachers had difficulty procuring supplementary science books for children at appropriate grade levels. Some personality traits possessed by teachers were retarding influences to science teaching. Over 50 per cent lacked confidence in performing demonstrations, in doing experiments, and in dealing with living things.

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POOLER, ROBERT L. Determination for the Modal Age Level for the Grades IV and VI of the Difficulty of the Principle, "The More Rapid the Vibrations of a Body the Higher is the Pitch of the Note Emitted By It." M.A. in Ed., 1954, Boston University, Boston, Massachusetts.

Major Faculty Adviser.—Dr. John G. Read.

Problem.—To discover the grade placement of the principle, "the more rapid the vibrations of a body, the higher is the pitch of the note emitted by it."

Procedures.—An experiment was carried on at the fourth and sixth grade levels. Lecture-demonstration type of instruction was used to illustrate the principle of pitch. The pupils were tested and restested.

Major Findings and Conclusions.—Sixth grade pupils had a better grasp of the test items than fourth grade pupils. It was recommended that this principle probably should be taught at the sixth grade level.

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RANK, RONALD I. A Correlation of the Fundamental Systems of Electrical Units. M.S., 1954, Northern Illinois State Teachers College, DeKalb.

Major Faculty Adviser.—Mr. Wallace B. Miner.

Problem.—To present information on the most common systems of electrical and magnetic units for the beginning student in physics.

Procedures.—A study of the literature and textbooks in physics was made.

Major Findings and Conclusions.—The paper is a summary of three basic systems of electrical units. The fundamental defining equations of the basic unit in each system is derived and each of the units of charge, electric field intensity, electromotive force, potential, capacity, electrical displacement vector, intensity, magnetic permeability, inductance, and total flux are compared as to their dimensions in terms of force, length, and time.

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ROBINSON, MYRON. Attitude Change as a Function of Communication Intensity and Audience Predispositions: An Experimental Study of Emotional Appeals. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Dr. J. Darrell Barnard.

Problems.—To analyze the relationship between the emotional intensity of a persuasive communication and the effectiveness of the communication in producing attitude change. A secondary purpose of the study was to study the interaction between individual predispositions and the stimulus material in the determination of patterns of response.

Procedures.—Three versions of an Army orientation film were prepared which differed in the amount of anxiety inducing stimulus material by editing out selected portions of the original film. At each of several experimental sessions the students were randomly assigned to four identical rooms with built in projection facilities. Each of three groups viewed one version of the film, and the fourth served as a control. Prior to the film presentations the groups took the Rosenzweig Picture-Frustration Test, and after viewing the films the students filled out a series of three attitude scales and a questionnaire.

Major Findings and Conclusions.—There was evidence of systematic attitude change as a result of increased communication intensity. However, an "analysis of variance" between experimental groups failed to yield significant differences. On the other hand, when an "analysis of covariance" was performed, using the scores obtained on the Picture-Frustration Test as the "matching" variable, and the attitude scores as the "test" variables, several significant differences did appear in the predicted direction. The major recommendation of the study relates to the necessity of examining personality characteristics of audience members whenever attempting to predict attitude change resulting from emotional appeals. The findings emphasize the fact that mere analysis of the stimulus material (communication content) is not in itself a sufficient basis for predicting the effects of emotional appeals.

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SCIENCE COUNCIL OF THE ST. LOUIS PUBLIC HIGH SCHOOLS. Summary of the Science-Mathematics Survey. 1954, St. Louis Public Schools, St. Louis, Missouri.

Problem.—To determine the desirability of science and mathematics in certain vocations.

Procedures.—A questionnaire was sent to 168 firms and industries in St. Louis, Missouri, and 60 per cent were completed and returned.

Major Findings and Conclusions.—Of the vocations listed, mathematics and science were needed less by bricklayers and plumbers. However, in these two vocations one-fourth of the persons checking the questionnaire indicated some high school mathematics and science would be desirable.

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SERVICE, FRED J. An Investigation of the New York State Regents Examination in Earth Science. M.A., 1954, Western Michigan College of Education, Kalamazoo.

Major Faculty Adviser.—Dr. George G. Mallinson.

Problem.—To item analyze and evaluate 1,825 completed and graded Regents Examinations of the University of the State of New York prepared for earth science for June 20, 1954.

Procedures.—Coefficients of correlation were computed to determine the validity of the test with respect to the extent to which it measures understandings of scientific principles, development of scientific attitudes, and attainment of problem-solving skills. The extent to which the items on a test discriminated or did not discriminate between students of high and low scores was determined.

Major Findings and Conclusions.—For the examination for June 20, 1950, the coefficient of correlation (reliability) is $.85 \pm .01$. This coefficient of correlation is significant at the one per cent level of confidence. For the examinations for June 20, 1950, the coefficient of correlation (consistency) is $.42 \pm .02$. This coefficient of correlation is significant at the one per cent level of confidence. If Part I measures chiefly factual information, and Part II emphasized the other

objectives of science teaching, then it seems likely that the more emphasis that is placed on facts, the less likely is the student to achieve in the broader objectives in science teaching, or vice versa. The data fail to show that the Regents Examinations in Earth Science for June 20, 1950, are reliable, consistent, or valid.

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SMITH, GRACE A. Science Interests of First Graders and Some Science Units Based on These Interests. M.A., 1954, Ball State Teachers College, Muncie, Indiana.

Major Faculty Adviser.—Dr. Robert H. Cooper.

Problem.—To develop selected science units based on the interest of first-grade children.

Procedures.—In a first-grade class, fifteen minutes a day were devoted to planning, discussing, reading, and experiencing field trips related to scientific principles. Pupils were carefully observed as to their science interests.

Major Findings and Conclusions.—These units held greatest interest for first-grade children: (1) weather, (2) animals, (3) air, (4) aviation, and (5) seeds.

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SMITH, RUBY DIAL. An Annotated Science Bibliography for Grades Four, Five, and Six. M.Ed., 1954, University of Texas, Austin.

Major Faculty Adviser.—Dr. Thomas D. Horn.

Problems.—To describe the fundamental science concepts to be presented at the intermediate elementary school level and to compile a selected bibliography to be used by elementary school teachers and pupils in the science area.

Procedures.—(1) A topical list of science concepts presented by the science textbooks adopted by the State of Texas was made. (2) An extensive study of library materials, especially trade books, was made and the titles classified according to the topical list of science concepts.

Major Findings and Conclusions.—Annotations were completed, including author, title, illustrator, publisher information, cost, suggested grade level, noted if listed in Children's Catalog, and a short paragraph as to what the book contained. Only the most frequently occurring topics, as tabulated from the State adopted texts, were included in the bibliography.

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SOLLBERGER, DWIGHT E. Teaching Combinations of Science Teachers in Pennsylvania. 1954, State Teachers College, Indiana, Pennsylvania.

Problem.—To determine teaching combinations of science teachers in Pennsylvania.

Procedures.—A questionnaire was sent to the science teachers of Pennsylvania.

Major Findings and Conclusions.—The teaching combinations of 1,500 teachers were tabulated. This is approximately one half the science teachers in Pennsylvania.

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STRAATMAN, ZEGER WILLIAM. Resource Units for a Course of Study in Health and Personal Development for Sixth Grade Students. M.Ed., 1954, University of Washington, Seattle.

Major Faculty Adviser.—Dr. Alice H. Hayden.

Problem.—To prepare a series of health education units for sixth grade elementary school children.

Procedures.—A study was made of pertinent literature in the field.

Major Findings and Conclusions.—A unit was developed to produce (1) better social relationships, (2) better health behavior patterns of everyday living, (3) understanding of family problems, (4) ability to take part in community responsibility, and (5) ability to assist in illness and emergency.

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SULLIVAN, W. BLAIR. A Survey of the Facilities for the Teaching of Selected Biological Laboratory Units in the Secondary Schools of Madison County. M.A., 1954, Ball State Teachers College, Muncie, Indiana.

Major Faculty Adviser.—Dr. Donald E. Miller.

Problem.—To survey the laboratory facilities in ten high schools in Madison County, Indiana, for teaching three selected units in biology.

Procedures.—By means of a checklist, the investigator interviewed biology teachers in Madison County, Indiana, to discover whether laboratory facilities were present, lacking, or inadequate in the respective high schools for the instruction of three selected biological laboratory units.

Major Findings and Conclusions.—Facilities for teaching elementary bacteriology were inadequate in 80 per cent of the high schools. Ninety per cent of the high schools had complete facilities for laboratory instruction in the dissection of preserved animals. All high schools had quite complete facilities for laboratory instruction in cell study.

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URWILER, DONALD HENRY. An Evaluation of Instructional Materials in General Science at the Ninth Grade Level for the Small Secondary School. M.Ed., 1954, University of Washington, Seattle.

Major Faculty Adviser.—Dr. Alice H. Hayden.

Problem.—To evaluate the instructional materials in general science in the ninth grade.

Procedures.—A study of the literature of visual aids was made.

Major Findings and Conclusions.—In the report the object, specimen, and model were considered. The field trip was discussed as an aid closest to reality and as one of the most valuable aids if properly used. The motion picture was considered. Still pictures and graphic materials were covered us a unit, and it was stressed that where motion is not essential the film strip is superior to the motion picture. Radio, recordings, and transcriptions were covered as a group. Television, the newest aid available to schools, was discussed.

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VONEIDA, THEODORE J. A Guide to Course Content and Demonstration Materials for Neuro-

muscular Physiology. M.Ed., 1954, Cornell University, Ithaca, New York.

Major Faculty Adviser.—Dr. Philip G. Johnson.

Problem.—To develop a course of study in neuromuscular physiology which will best fit the needs of the physiotherapy student.

Procedures.—The material was gathered from (1) textbooks of histology, anatomy, embryology, and physiology, (2) personal conferences with other members of the teaching profession, (3) lecture notes taken by the author during the past five years, and (4) actual clinical experiences of the author, combined with his experiences and reviews of previous New York State Board Examinations in physiotherapy.

Major Findings and Conclusions.—A course of study and many visual aids were developed.

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WALLIN, RUSSELL SMITH. The Teaching Values of the Commercially Prepared Biology Drawings Versus the Original Detailed Laboratory Drawings. Ed.D., 1954, Syracuse University, Syracuse, New York.

Major Faculty Adviser.—Dr. Alfred T. Collette.

Problem.—To prove or disprove the following hypothesis: Students labeling and using commercially printed drawings will equal or surpass the achievement gain in factual knowledge made by students completing and labeling detailed freehand drawings.

Procedures.—This investigation was conducted at the State University Teachers College at Brockport, New York, utilizing the data secured from 195 sophomore students enrolled in the one-year course entitled "General Biology" during the years, 1951–1952 and 1952–1953.

Major Findings and Conclusions.—The students who labeled and used commercially printed drawings equalled or surpassed the achievement gain in factual knowledge made by students who completed and labeled detailed free-hand drawings.

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WALSH, WILLIAM JAMES, JR. The Status of the Science Methods Course for Secondary Teaching in Selected State Colleges and Universities in the United States—1954. Ed.D., 1954, University of Colorado, Boulder.

Major Faculty Adviser.—Dr. Stanley B. Brown.

Problems.—To ascertain the general nature, equipment, facilities, materials, and implications of the science methods course.

Procedures.—Investigation procedure included the examination of literature in the fields related to the problem and a questionnaire survey of accredited State supported institutions offering secondary school science training.

Major Findings and Conclusions.—(1) Approximately two-thirds of the institutions engaged in the preparation of secondary school science teachers offered a science methods course. (2) The preference of three-fourths of the schools offering the course was for a single science methods course for all prospective science teachers, regardless of specific subject matter area of specialization. (3) The size of the class generally was less than ten students, the majority of which were seniors. (4) Fifty per cent of the schools indicated individual teacher rather than cooperative planning. (5) Demonstration and student supplies in the areas of chemistry, biology, physics, and audio-visual materials were adequate for the activities required by the curricula in the individual schools. Construction equipment for demonstration and building of equipment was noticeably inadequate.

* * *

WASHTON, NATHAN S. Applying Biological Principles to Physical Sciences. 1953, Queens College, Flushing, New York.

Problem.—To determine the applications of several biological principles to a generalization, concept, principle, or problem in the physical sciences, astronomy, chemistry, geology, or physics.

Procedures.—A sample of five principles of biology for general education was listed in a questionnaire. Fifty questionnaires were returned by members of the National Association for Research in Science Teaching representing all of the areas in the natural sciences. They were asked to list those generalizations or principles in the physical sciences which would help students understand the specified biological principle. This was done individually for each of the five biological principles that appeared in the questionnaire.

Major Findings and Conclusions.—The findings in this study indicate that several biological principles may be applied to concepts or topics pertaining to energy, chemical change, catalysis, molecular theory, diastrophism, erosion, orogeny, isostasy, and mechanics of liquids. It is suggested that experimental syllabi be developed for science courses for general education.

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WEAVER, ALLEN DALE. A Determination of Criteria for Selection of Laboratory Experiences Suitable for an Integrated Course in Physical Science Designed for the Education of Elementary School Teachers. Ph.D., 1954, New York University, New York City.

Major Faculty Adviser.—Professor Cyrus W. Barnes.

Problem.—To develop laboratory experiences suitable for an integrated course in physical science for prospective elementary school teachers.

Procedures.—A list of forty-three criteria for the selection of laboratory experiences was developed by adaptation of pronouncements of authorities in the field of science education. These criteria were evaluated in terms of the objectives by a jury of sixteen teachers of physical science in teachers colleges throughout the nation. Six of the criteria were rated essential and thirty-six desirable. Fifty-five experiences were constructed and/or selected and revised by the investigator to meet the six essential criteria, and as many of the desirable criteria as possible for each experience. Another jury like the one mentioned above evaluated a sampling of eighteen of these experiences in terms of the criteria.

Major Findings and Conclusions.—In the judgment of the investigator, based upon his experience in using the experiences in a physical science course for the training of elementary school teachers, and based upon the judgment by the jury in terms of the criteria of the sampling of eighteen experiences, the fifty-five experiences presented in this study include more than enough highly desirable experiences for a course offering one two-hour laboratory period per week for thirty-six weeks.

* * *

Wedul, Melvin Oliver. Conservation Education in Selected Minnesota Elementary Schools and State Teachers Colleges, 1954. Ed.D., 1954, University of Colorado, Boulder.

Major Faculty Adviser.—Dr. K. L. Husbands.

Problem.—To determine the status of conservation education in selected Minnesota elementary schools and State teachers colleges.

Procedures.—A study of the elementary school situation was made through questionnaires and interviews. The college information was obtained through written correspondence and conference with representatives of the colleges. Questionnaires were sent to 475 teachers in 9 counties and 428 usable responses, or 90 per cent, were returned. Fifty-eight elementary school teachers and all nine county superintendents were interviewed. Conferences were also held with several principals and superintendents.

Major Findings and Conclusions.—It was found that 96 per cent of the teachers had more than one year teaching experience. Fourteen per cent of the teachers had no training for conservation education. Minnesota State teachers colleges had provided all or part of the formal education beyond high school for 72 per cent of these elementary school teachers. Integration with science and social studies was the most common practice in teaching conservation. Less than half the teachers used the audio-visual aids. Less than half the teachers used indoor conservation projects, less than one-fifth used outdoor projects, and about one-third of the teachers used resource personnel. Four of the five teachers colleges offered separate courses in conservation education.

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West, Mary Alice. Environmental Resources for the Teaching of Science in the Primary Grades. M.A., 1954, Ball State Teachers College, Muncie, Indiana.

Major Faculty Adviser.—Dr. Robert H. Cooper.

Problem.—To develop science units of study that use the Belle Gregg community resources.

Procedures.—Science resources near the Belle Gregg School were listed, mapped according to location, distance, and values, and used to develop five major units in science.

Major Findings and Conclusions.—Science resources are plentiful in the region surveyed. The five units developed were: (1) Rocks All Around Us, (2) Water Is Important, (3) Animals Are Almost Everywhere, (4) Let's Find the Easy Way, and (5) Trees Grow from Seeds.

THE TEACHING OF BASIC PREMISES AS AN APPROACH TO SCIENCE IN GENERAL EDUCATION *

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A. *The Need for a Common Ground*

Modern man lives in a science-oriented world. This fact is apparent to each of us every day, in all fields of activity. At a rapidly accelerating pace both the results of scientific research and the method of thinking of science have been penetrating every phase of modern life. Unfortunately for the development of an adequate understanding of the problems raised by the impact of science upon our world, the results have penetrated faster than the method of thinking. The problem of the general education movement, as it applies to science teaching, is to equalize the extent of this penetration and to push forward an understanding of both aspects of it.

A major difficulty which confronts those who plan for the teaching of science in general education at the college level has been the existence within the general field of science of several well-defined and nearly autonomous sub-fields or disciplines, each having a long and proud history and an educational tradition of its own. Within this history and tradition the teachers and investigators of each area have received their training, with only such crossing-over into other areas as has been permitted

* Contribution No. 3, Department of Biology, Western Michigan College.

under the college and graduate school major-minor system. All of these disciplines have generated fierce internal loyalties, and within their boundaries the elementary, advanced undergraduate and graduate courses of college and university departments have been planned and taught.

The general education movement in college science teaching was not something which grew from within the traditional fields of science instruction, but rather something which was imposed upon them from outside. It was an idea of the educators which science teachers have adopted reluctantly. Nevertheless, forward-looking science teachers recognize the crying need for interpreting science to laymen, represented in our colleges and universities by students majoring in the social sciences, English, the humanities, foreign languages and other traditional academic fields, as well as those who are going directly into preparation for the vocations. This recognition is coupled with the necessity of making as meaningful as possible the college requirement of a limited number of credit hours of science for graduation with a college degree. Therefore there has come a realization that scientists must take matters into their own hands and explore for themselves this area which the educators have broadly defined.

Any practical attempt to implement such a task, however, quickly runs into the difficulty that no truly general picture of science exists. For practical teaching purposes there is no such thing as "science." There are only "sciences." It is of course possible to state broad definitions of science, but these always dissolve at the level of classroom presentation into specific fields, such as chemistry, physics, astronomy, and biology; or even into more detailed specifics such as paleontology, zoology and botany. Teachers of the humanities have been able to discern certain basic principles which operate throughout the areas of music, art, and literature, and teachers of the social sciences have been similarly able to interrelate history, economics, political science, and sociology. Most attempts at a common presentation of natural science, however, have resulted only in the bringing together of a hodge-podge of materials drawn from separate fields. Thus we have the so-called science survey or "smorgasbord" course which has been aptly labelled "a little of this and a little of that and not much of anything."

Most attempts which have been made to solve the problem of developing a common ground for the natural sciences have taken the direction of defining a methodology which is basic to all sciences. The statement is frequently made in connection with the deliberations of college curriculum committees which are trying to set up alternative ways of meeting the "science requirement" for graduation, that the student may take a set number of credit hours of either physical science or biological science because "the important thing is that he become acquainted with the scientific method." It is assumed that an understanding of the scientific method can be acquired equally well in any science. Therefore, so long as some science is included as a part of the curricular pattern the requirement is considered to be adequately fulfilled. Is this true? Is there such a thing as "the scientific method" which is common to all sciences? We have been told by investigators of the history of science that there is no one scientific method, but rather "scientific methods" which are more or less related to one another.

What then is held in common by the fields of science, if anything? Is it possible that we may have in the "scientific point of view" or "scientific attitude" a more fundamental basis for seeing science as a whole? Scientific method or related scientific methods are apparently limited to dealing with repeatable phenomena which can be weighed, measured, counted or otherwise quantitatively dealt with.

This would appear to exclude important portions of man's world, and at the same time to place certain limitations on the applicability of scientific method. The entire realm of values, for example, is certainly beyond the scope of the scientific method, defined in this way. Even some disciplines which are generally considered to be a part of science, notably psychology, lie at least partially outside the area to which scientific method can be readily applied. The attitude of science, however, including such commonly accepted elements as objectivity and tentativeness, would appear to be applicable to all or practically all aspects of human thought and action.

It seems possible that scientific attitude, carefully defined and extended, may constitute not only the most important fundamental for understanding the scientific process and the most successful basis for integrating the various special fields of science for presentation to the non-scientific person, but also it may be the most important philosophical contribution which the scientific movement has made and can make to the thinking of modern man. It is probable that if scientific method were completely erased from human memory, it would be quickly re-born if scientific attitude were still present. But if scientific attitude were destroyed, as indeed appears to be taking place in connection with certain modern political ideologies, then scientific method, at least in its more fruitful and original aspects, would wither and die.

We may picture science as a pyramid, each of whose sides represents a scientific subject matter field, but whose top represents a point of view common to all science, and toward which all scientific studies ideally lead. You may approach this point of view, utilizing the subject matter of any field of science as a means of getting there. Our problem is to define this common point of view in specific terms, and to find a way of presenting it to the general student in non-technical fashion. If this can be done, in terms of any scientific subject matter field or combination of fields, then we have arrived at a major discovery in the field of general education as well as an important philosophical delineation of what science is. Undoubtedly the common ground, if it exists and is definable and teachable, constitutes one of the understandings which is most needed by laymen who must live in our science-oriented world. A recent group of educators, working on the evaluation of science learning in general education at the college level, referred to our sought-for common ground as "understanding the point of view of a scientist and the kinds of things that he does."* This paper constitutes an attempt to explore the implications of the problem of a common ground.

B. *A Tentative List of Basic Premises*

A number of years ago the writer became interested in the possibility of developing a set of statements which would serve to define the point of view of a scientist, or the scientific attitude. These statements were tested and re-shaped in conversations and correspondence with colleagues, and in classroom presentations and informal discussions with students. As a result of this extended process the original statements were modified and new ones were added. The list which is presented here is still tentative and must necessarily remain so. No claim of either completeness or finality is made for it. Most science teachers who have seen the statements disagree with some of them, but there is no general agreement as to the ones with which they disagree.

Some of the statements refer to the manner in which a scientist approaches

* The Science Committee of the Cooperative Study of Evaluation in General Education of the American Council on Education (see Bibliography).

his problems. Others constitute basic assumptions which appear to underlie all scientific thinking. Still others involve the limitations of science and a kind of scientific "faith" or confidence which appears to approach the character of philosophical belief. All of them constitute descriptions of the way scientists appear to behave rather than prescriptions of how they must behave. Therefore, they have the character of all scientific generalizations in that they are subject to continual modification if further observation of the behavior of scientists fails to confirm them. Although these principles belong to science as a whole, some of them lean more heavily on biological science or on physical science, and in some cases the delineation of them was first accomplished in a particular subject matter field and later applied to others.

The list follows:

1. *Principle of Objectivity*
   A scientist cultivates the ability to examine facts and suspend judgment with regard to his observations, conclusions and activities.
2. *Principle of Tentativeness*
   A scientist does not regard his generalizations as final, but is willing to modify them if they are contradicted by new evidence.
3. *Principle of Consistency*
   A scientist assumes that the behavior of the universe is not capricious, but is describable in terms of consistent laws, such that when two sets of conditions are the same, the same consequences may be expected.
4. *Principle of Uniformity*
   A scientist believes that the forces which are now operating in the world are those which have always operated, and that the world and the universe which we see are the result of their continuous operation.
5. *Principle of Causality*
   A scientist believes that every phenomenon results from a discoverable cause.
6. *Principle of Parsimony*
   A scientist prefers simple and widely applicable explanations of phenomena. He attempts to reduce his view of the world to as simple terms as possible.
7. *Principle of Materiality*
   A scientist prefers material and mechanical explanations of phenomena, rather than those which depend on non-material or supernatural factors.
8. *Principle of Dynamism*
   A scientist expects nature to be dynamic rather than static, and to show variation and change.
9. *Principle of Relativeness*
   A scientist thinks of the world, and of the phenomena in it, as consisting of sets of relationships rather than absolutes.
10. *Principle of Intergradation*
    A scientist thinks in terms of continua; he distrusts sharp boundary lines, and expects to find related classes of natural phenomena grading imperceptibly into one another.
11. *Principle of Practicality*
    A scientist expects that in any situation involving competition among units of varying potentialities, those which work best under existing circumstances will tend to survive and be perpetuated.
12. *Principle of Continuous Discovery*
    A scientist hopes that it will be possible to go on learning more and more about the material world and the material universe of which it is a part, until eventually all may be understood.
13. *Principle of Social Limitation*
    The social framework within which a scientist operates may determine and limit the kinds of problems on which he works and the data which he collects, and may also influence his conclusions.
14. *Principle of Complementarity*
    A scientist attempts to incorporate all phenomena into a single consistent, natural scheme, but he recognizes that contradictory generalizations may be necessary to describe different aspects of certain things as they appear to us.

The Principles of Objectivity and Tentativeness serve to define the way in which a scientist approaches his world. Of course, it is recognized that these statements represent an ideal. Scientists are human, and they may and do not always keep their emotions out of their work. Indeed the writer has seen scientists who lost all objectivity and tentativeness when a particular interpretation of nature which they had espoused was challenged by a colleague. Nevertheless it is through a consistent application of objectivity and tentativeness to the problems of nature that science has advanced and the present body of scientific knowledge has been accumulated.

The scientist's laws are essentially descriptions of how nature has been observed to behave. They have been arrived at objectively and without reference to how

the scientist would like the world to behave. Furthermore these laws are tentative and must inevitably remain so. They are always subject to modification if new evidence contrary to them is discovered. The scientist approaching an experiment or observation which is expected to follow a certain law is in the position of saying: "The ten thousand cases of this type which have been observed have behaved in such and such fashion. Therefore, I expect, on the basis of the Principle of Consistency and the Law of Probability that the ten thousand and first case which I am about to observe will behave in the same or an understandably related fashion." A scientific theory has a higher probability value than an hypothesis, and a scientific law has a higher probability value than a theory, but no scientific law could ever become absolute unless it were to describe an infinite number of cases.

The Principles of Consistency, Uniformity and Causality are statements of how the scientist expects his world to behave. We have just indicated that the idea of consistency enters into the whole concept of scientific law. Scientists believe that the universe and our world which is a part of it behave in a consistent and predictable fashion, both on a long-term and a short-term basis. They believe that you can find out about this behavior simply by watching it, and that when you have done so for long enough you can make workable probability judgments about future behavior.

Consistency and uniformity constitute two faces of the same fundamental idea. Consistency applies to the here and now, the day-to-day, this experiment, this particular observation. Uniformity refers to the long look, the vast reaches of past and future evaluated in terms of the present. The idea of uniformity belonged originally to the geologist, but it has proved equally applicable in all areas of science. The scientist observes the natural processes and forces at work around him, and projects or extrapolates them into the understandable past and the predictable future. He believes that the world which we now see is the result of their operation, and that the world of the future will be shaped by them.

Because of a belief in uniformity the scientist dislikes the idea of unique events, things which happen once under special conditions and never happen again. Conceivably the same special conditions could arise again under the same circumstances and produce the same event, and thus not violate the idea of uniformity, but the scientist would prefer to think of natural forces as operating in the same way and bringing about the same kinds of events over and over again, with only slow and progressive changes and without the occurrence of radically different situations. It is in connection with the idea of uniformity that science runs afoul of many traditional religious beliefs.

The idea of causality in the commonly accepted sense has come in for much serious questioning by modern physicists. It appears to break down at the level of ultimate particles whose behavior is describable only on the basis of the Law of Probability. Perhaps in this fact lies the chief hope of man for the existence of something like free will in the material world. Nevertheless, scientists proceed for practical purposes on the basis that if a thing happens in nature there must be a natural cause for it.

Related to the scientists' use of the idea of causality is his abhorence of teleological interpretations and implications. To go from a scientific study of relationships and functions in nature to the idea of purpose behind nature involves the taking of a "mental leap." A scientist is perfectly free to take this leap as an individual, but he must not claim a scientific basis for having done so. In general, the scientist is concerned with questions of "how" rather than questions of "why", although he can deal with a kind of "how-why", or an operational "why". His method limits

him to questions of this sort. He cannot use it to deal with the idea of a First Cause.

The Principles of Parsimony and Materiality set forth the ways in which a scientist prefers to decribe his world. He seeks for simple, material explanations of phenomena. He does not resort to any other type of explanation or description until he has exhausted the possibilites of these.

The Principle of Parsimony is essentially a re-statement and application of Occam's Razor: "Entities should not be multiplied beyond necessity." It functions in connection with biological classification, and with present theories of the structure of matter in which the ninety-two naturally-occurring chemical elements are reduced to variations in numbers and arrangement of a few kinds of fundamental energy particles. It furnishes a partial basis for the development of Einstien's Unified Field Theory in its attempt to draw together hitherto unrelated areas of physical phenomena.

Nevertheless in the face of contrary evidence the idea of parsimony may be shelved and a more complex explanation may be accepted instead of a simple one. In the case of evolution the Lamarkian hypothesis of change of species through the inheritance of characteristics acquired through use and disuse was a simpler explanation than that afforded by the natural selection of naturally-occurring variations, some of which were heritable and some not so. Nevertheless as a result of the accumulation of no substantial evidence for the simple hypothesis and overwhelming evidence for the more complex one, the latter was the one that was accepted. It isn't always nature that works on the basis of parsimony; it is the scientist's mind that goes as far in this direction as nature permits it to.

The Priniciple of Materiality does not forbid the scientist's believing anything which appears to lie beyond the material. It merely demands that he exhaust the possibilities of material explanations before going beyond them. A primitive person, upon seeing someone struck and killed by lightning, might explain it as a blow struck by an angry God. Even today, some lay people might say that the man was killed as a "judgment" sent on him by God because of some sin that he had committed. A scientist, seeing the same thing would explain it solely on the basis of the physical laws that describe the behavior of atmospheric electricity. If he went beyond the "how" of the event, and that portion of the "why" of it which had to do with the man's being in that particular place at that particular time, and dying as a result of electrical shock, he might, if he were a religious person, consider the possibility of a larger "why", having to do with the person's sin and God's working through natural laws to bring about divine justice, but in this he would be going beyond the bounds of science, and he would recognize that he was doing so.

If a scientist attended a spiritualist seance at which apparently supernatural phenomena were taking place, he would first satisfy himself that the phenomena which he observed were real and not illusory, genuine and not faked, and then he would exhaust every possible avenue of explanation of them on a natural basis, and possibly set forth the idea that they might depend on natural forces which were as yet unknown, before he would consider an explanation of them on a supernatural basis.

The Priniciples of Dynamism, Relativeness, Intergradation and Practicality constitute the boundary posts of the kind of world which the scientist believes that he has found. It is a dynamic world rather than a static one. It is a world of relationships rather than absolutes. It is an intergrading world in which there are no clear-cut "blacks" and "whites", but only shades of gray that merge and blend. Furthermore it is a world in which the ever-present question is: "Does it work? Is it operationally valid?"

At first glance it might appear that the idea of dynamism clashes with that of consistency. This is not necessarily so. The scientist expects change. He recognizes at least three kinds: patternless change, directional change and cyclic change. The interrelationships of these three types is an interesting topic in its own right. The changes which the scientist expects occur within a range of variation, and he seeks to discover patterns within this range. Descriptions of these consistent patterns of change constitute scientific laws.

The origin of the idea of relativeness belongs to the field of physics. Modern physicists have discovered that entities which were formerly thought to be completely independent of one another are dependent for their very nature on their relationships. Thus matter and energy, space and time, have come to appear merely as different aspects of the same things and to have no absolute identity of their own. Einstein's theory of relativity, set forth in the early years of the present century, is the center of much of this developing understanding of interrelationships. The same idea is now diffusing outward into all other fields of science. The whole natural world appears to be dissolving into sets of relationships. Non-scientific fields are also feeling the penetrating force of the idea of relativeness. In human relations, in politics, and even in ethics the old absolutes are disappearing. The idea of relativeness has important implications for religion which have not yet been adequately explored.

We are coming to recognize what might be called "the inevitability of uncertainty." We can only be sure of the particular set of relationships that we are studying. We may speculate on what lies beyond them but we cannot be certain, and we must recognize that probably the very "hard facts" that we are studying, placed under a different set of circumstances might mean something quite different from what they mean to us. Correlated with this is the impossibility of "getting outside ourselves" to find out if our view of the world is a correct view. We must recognize, theoretically at least, the possibility of existence of other views of the world based on other types of sense organs and other types of minds, which would deal with the same data that we have but do so differently, and would arrive at conclusions which, given their starting point, would be as "correct" or "true" as ours.

The idea of intergradation has its origin in the field of biology. The biologist recognizes that species and races intergrade, even though he divides them for purposes of convenience in classification. The psychiatrist recognizes that the abnormal intergrades with the normal, even though he orders one individual to be hospitalized for schizophrenia and allows another to walk the streets. All of us who are teachers know that unsatisfactory work in a course grades imperceptibly into satisfactory, even though for practical purposes we have to give grades that presumably have definite meanings, and fail one student and pass another who is very little better. Even in the physical sciences the phenomena of intergradation are operative. The artificially radioactive isotopes of chemical elements in some cases represent a kind of "borderline condition" between two stable elements. The scientist has found few or no sharp lines in nature when he has succeeded in studying it on a broad enough basis.

The world which science has discovered is essentially a pragmatic one, in which that which works survives. This idea of practicality was also first developed by the biologists. It is, of course, the basic principle underlying the doctrine of evolution. Evolution, however, cannot operate in a static world. It involves also the idea of dynamism in the sense of constantly-occurring variation in living forms. Evolution, therefore, can be considered to be the result of the interaction of practicality and dynamism.

The application of the idea of practical-

ity actually goes much farther back than the biologist's discovery of its operation in connection with the evolution of living things. People have always proceeded on the basis of retaining "that which works best", and discarding that which does not work, or that which works less well. They have been forced to do so to survive at all. Indeed the application of practicality goes beyond man and permeates the whole natural world. It is an application of the trial-and-error procedure which is the basis of all problem-solving.

The Principles of Continuous Discovery and Social Limitation define (a) what the scientist believes to be his mission, and (b) the restrictions under which he necessarily works because of the nature of the society in which he lives. In a sense these two principles set the limits of the scientist's operations.

The idea of continuous discovery is an expression of the scientist's assumption that the whole material universe would be describable in terms of natural laws if it could be investigated completely. He is not prepared to admit that there are any material phenomena, or phenomena with material manifestations, which he may not permit himself to explore or which will not be amenable to his method of exploration. From the very beginning of the development of science, scientists have proceeded as if they could go on and on without limit until they came to understand all there was to understand about the physical universe and its workings. Upon this assumption they have built up the vast edifice of knowledge that we now have, and the practical applications of it that make modern life possible.

The idea of social limitation is one which may not be recognized by scientists themselves or even by the society of which they are a part. Even if it is recognized subconsciously it may be taken for granted and never verbalized. We are familiar with the fact that Soviet scientists are not free to explore certain areas of research because the findings in these areas conflict with Communist dogma. This is notably true of the field of genetics, where Marxism places emphasis on the influence of the environment as contrasted to heredity, and imposes a belief in the inheritance of acquired characteristics.

We do not ordinarily stop to think, however, that scientists in Christian countries cannot perform dangerous experiments on human beings, not even on condemned criminals whose lives society takes anyway. Even when such experiments would benefit the entire human race, they are forbidden because of the Christian emphasis on the value of the individual. Since Communism places the state or community above the individual, a scientist in a Communist country would presumably be permitted to perform experiments of this type. At least it would appear that there is nothing in the Communist ethic to forbid it, provided it had the sanction of the state. There are no scientists, therefore, who are free of social limitations. It is probable that a being from Mars would consider scientists in both Communist and Christian countries to be severely limited.

The influence which the social framework may have on the interpretations which a scientist makes and the conclusions that he draws is an even more subtle thing. Many of our scientific-philosophical ideas may have been influenced by the fact that we think with a Judeo-Greek-Christian background. It is at least conceivable that another group of minds coming upon the same problems from an entirely different background might have taken the same data that we used and reached different conclusions. To a certain extent we have something of this kind when Communists, who have a different interpretation of history and basis for reasoning from our traditional one, take a particular event or situation and derive an entirely different meaning from it.

The Principle of Complementarity is by its very nature controversial. It stands apart from all of the other premises that make up a scientist's point of view. One

aspect of it goes beyond science altogether, and yet it is based on solid evidence as to the ultimate nature of at least certain portions of the physical world, insofar as we have been able to explore them. From our standpoint it appears to contradict logic and common sense, and yet possibly it only serves to show the limitations of logic and common sense as we know them.

Complementarity was discovered by physicists in their attempts to deal with the phenomena of electromagnetic radiations, energy particles and atomic structure. Light and related electromagnetic phenomena are both wave-like and particle-like. Neither explanation is adequate alone. Both are necessary, although to a certain extent they are mutually contradictory. In a similar fashion, the fundamental energy particles that make up the structure of the atom behave like waves when in motion. It is probable that many other aspects of the physical universe likewise exhibit complementarity.

There are two ways of looking at the Principle of Complementarity. One of these involves a kind of faith on the part of scientists in the essential unity of nature. The other does not do so. We may assume under the first point of view that if we knew enough about the natural world its unity would be apparent. The second point of view recognizes a possible plurality in nature, and includes the idea that ultimate reality may be beyond our finite concept of unity, such that any attempt to reduce it to unity results only in "cutting it down to our size," and therefore necessarily leaves out a part of it.

C. *The Use of Basic Premises in Teaching*

If the basic premises are to be effective for purposes of general education in science, they must be teachable at the level of the non-specialized student, which usually means the student in the first two years of college. Furthermore the teaching of them must result in some measurable changes in the students who are taught.

For a number of years the writer has included the teaching of these basic premises in a unit called "The Nature of Science" in his biology course at Stephens College and at Western Michigan College. Illustrations for them are drawn, whenever possible, from both biological and physical sciences. The unit has also included material on inductive and deductive thinking, the nature of scientific laws and their relation to probability, and scientific methodology.

It seems probable that the use of a list of basic premises constitutes a valid approach to the problem of the teaching of science in general education at the college level, in that they represent a common ground on which scientists from various specialized subject-matter areas can get together. Of course it is only a foundational approach, since such basic premises can only be taught in terms of specific subject matter illustrations. They can also frequently be related, however, to every-day situations which have entered into the student's out-of-class experiences.

A partial approach to evaluation of an understanding of the basic premises is contained in tests prepared by the members of the Science Committee of the Cooperative Study for the Evaluation of General Education of the American Council on Education, mentioned earlier.* These tests attempt to ascertain the ability of the student to recognize the elements of scientific method and attitude which are contained in news articles and other writings at the non-technical level. The writer has made use of these tests in his classes in connection with the teaching of the unit on "The Nature of Science," and has obtained substantial percentage gains in post-test results over pre-test results.

If basic premises are to enter widely into general education science teaching, more attention must be given to evaluating an attainment of an understanding of them,

* "A Test of Science Reasoning and Understanding, Natural Sciences," Forms C and D. Cooperative Study of Evaluation in General Education of the American Council on Education, 1952.

and better methods of carrying out such evaluation must be devised. This will necessarily require the cooperative effort of science educators who represent different subject matter fields, and who are sincerely interested in the philosophy and practice of general education.

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THE SCIENCE BACKGROUNDS AND COMPETENCIES OF STUDENTS PREPARING TO TEACH IN THE ELEMENTARY SCHOOL

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INTRODUCTION

THE problem of subject-matter competence of teachers of science is one of long-standing and has been the subject of much discussion. As yet, however, no solution to the problem seems to be in sight. In a recent study Sturm[1] summarized a number of the findings of research on this problem in the area of secondary science thus:

1. The training of science teachers who teach at the high-school level is not as extensive as may be desirable.

2. Teachers of science at the high-school level tend to be better trained in factual information than in the ability to understand and use scientific principles.

3. The training of teachers of science at the high-school level tends to be unbalanced in the various areas of science.

A search of the literature for research studies that deal with the training in science of elementary teachers, however, fails to reveal any studies that were as extensive

[1] Sturm, Harold E. "A Study of the Subject-Matter Competencies in the Field of Science Possessed by Student Teachers Preparing to Teach Elementary School." Unpublished master's thesis, University of Michigan, Ann Arbor, Michigan, 1952. P. 14.

as those in the area of secondary science. Four publications [1, 2, 3, 4] that have appeared imply tacitly rather than directly that the training in science of elementary teachers has many of the same weaknesses as that of secondary teachers. In essence, the studies mentioned seem to indicate the following:

1. The training of both elementary and secondary science teachers tends to be inadequate in one or more ways.

2. The evidence of such inadequacy is less definite at the elementary level than at the secondary.

Hence, it would seem desirable that a more extensive and objective investigation be made of the subject-matter training of teachers of elementary science.

THE PROBLEM

The purpose of this investigation is (1) to determine the background and knowledge of the subject-matter of science possessed by elementary student teachers who were completing their training in the schools in which the investigators were employed; (2) to determine their attitudes and opinions concerning certain aspects of their preparation for teaching science; and (3) to compare their subject-matter competence in science with that of certain groups of high-school pupils.

THE BACKGROUNDS OF THE STUDENT TEACHERS AND THEIR ATTITUDES TOWARD SCIENCE COURSES

The first step was to construct a questionnaire that would determine both the extent of training in subject matter of science that the elementary student teachers possessed and their attitudes toward various fields of science. The questionnaire included also questions to determine the extent of the respondents acquaintance with, and attitudes toward, survey science courses at the college level; their estimates of their own competence to teach elementary science; and the amounts of science that they expected to introduce into their teaching.

Table I contains the facts concerning the science courses that these elementary student teachers had studied in high school.[1]

TABLE I

YEARS OF HIGH-SCHOOL SCIENCE TAKEN BY ELEMENTARY STUDENT TEACHERS

Number of Years	Student Teachers in School A		Student Teachers in School B	
	Number	Per Cent	Number	Per Cent
5.0	2	3.6	2	2.2
4.5	1	1.8	0	0.0
4.0	7	12.5	11	12.1
3.5	3	5.4	0	0.0
3.0	15	26.8	18	19.8
2.5	3	5.4	5	5.5
2.0	20	35.7	28	30.8
1.5	0	0.0	5	5.5
1.0	5	8.9	10	11.0
0.5	0	0.0	1	1.0
0.0	0	0.0	11	12.1
	56	100.0	91	100.0

Findings

1. Ten of the elementary student teachers in School A had taken four or more years of work in science at the high-school level, while thirteen in School B had done likewise.

2. Only five of the elementary student teachers in School A had taken less than two years of work in science at the high-school level, while twenty-seven in School B had taken less than two.

Table II presents facts relative to the high-school science preparation of the elementary student teachers.

[1] Blough, Glenn O., and Huggett, Albert J. *Elementary School Science and How to Teach It.* New York: The Dryden Press, 1951. Pp. xi + 532.

[2] Mallinson, George Greisen. "Preparing Critic Teachers to Supervise and Teach Elementary Science," *Science Education,* XXXII (October 1948), 254–8.

[3] Mallinson, George Greisen. "State Requirements for Certification of Teachers of Elementary Science," *Science Education,* XXXIII (October 1949), 290–2.

[4] Powers, Leversia L. "Curriculum Planning for the Elementary Schools of Pennsylvania," *Science Education,* XXXII (October 1948), 238–42.

[1] In the tabulations that follow the schools from which the data were obtained are identified as School A and School B.

TABLE II

COURSES IN HIGH-SCHOOL SCIENCE TAKEN BY ELEMENTARY STUDENT TEACHERS AND THEIR ATTITUDES TOWARD THEM

	Students Who Had Taken the Course				Students Who Had Wanted to Take the Course				Students Who Had Avoided or Had Tried to Avoid Taking the Course			
	School A		School B		School A		School B		School A		School B	
Subject	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Chemistry	47	83.9	62	31.6	33	58.9	37	29.8	13	23.2	25	38.5
Biology	45	80.4	58	29.6	34	60.7	39	31.5	5	8.9	11	16.9
General science	28	50.0	38	19.4	15	26.8	21	16.9	6	10.7	8	12.3
Physics	27	48.2	29	14.8	23	41.1	20	16.1	15	26.8	14	21.5
Physical science	0	0.0	7	3.6	0	0.0	4	3.2	0	0.0	4	6.2
Earth science	3	5.4	1	0.5	2	3.6	2	1.6	3	5.4	3	4.6
Physiology	3	5.4	1	0.5	2	3.6	1	0.1	0	0.0	0	0.0

Findings

1. In both Schools A and B more elementary student teachers had taken chemistry in high school than any other science; fewer had taken earth science and physiology than any other science. This may be explained partially by the fact that earth science and physiology are rarely offered as separate courses at the high-school level.

2. In both Schools A and B more of the elementary student teachers had wanted to take biology in high school than any other science; fewer had wanted to take earth science and physiology than any other science.

3. The subject in science that elementary student teachers in School A had avoided or tried to avoid most often in high school was physics; in School B, was chemistry. In both Schools A and B the subject they least often avoided or tried to avoid was earth science.

Table III presents facts relative to the preparation of the elementary student teachers with respect to the number of semester-hours work in college courses of science they had completed.

Findings

1. The number of semester hours of science work taken in college by the elementary student teachers ranged from 0 to 67 in School A and from 0 to 60 in School B.

2. Two of the elementary student teachers in each of Schools A and B had taken no courses in science at the college level.

3. The mean number of semester hours of science work completed by the elementary student teachers in School A was *15.1*

TABLE III

SEMESTER HOURS OF COLLEGE SCIENCE COMPLETED BY ELEMENTARY STUDENT TEACHERS *

Number of Semester Hours	Number of Students	
	School A	School B
0– 5	3	5
6–10	6	16
11–15	27	32
16–20	13	26
21–25	2	5
26–30	3	4
31–35	1	0
36–40	0	2
41–45	0	0
46–50	0	0
51–55	0	0
56–60	0	1
61–65	0	0
66–70	1	0
	56	91

* In School B courses in Geography are considered as being science courses. In School A they are not.

TABLE IV

COURSES IN COLLEGE SCIENCE TAKEN BY ELEMENTARY STUDENT TEACHERS AND THEIR ATTITUDES TOWARD THEM

	Students Who Had Taken the Course				Students Who Had Wanted to Take the Course				Students Who Had Avoided or Had Tried to Avoid Taking the Course			
	School A		School B		School A		School B		School A		School B	
Subject	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Zoology	34	60.7	22	9.3	23	41.1	12	7.7	9	16.1	10	9.3
Geology	31	55.3	3	1.3	22	39.3	3	1.9	4	7.1	3	2.8
Botany	30	53.6	17	7.2	21	37.5	8	5.2	6	10.7	9	8.4
Health education	21	37.5	47	19.9	15	26.8	40	25.8	2	3.6	2	1.9
Chemistry	16	28.6	10	4.2	8	14.3	7	4.5	23	41.1	18	16.8
Astronomy	10	17.8	2	0.8	9	16.1	2	1.3	8	14.3	0	0.0
Biology	9	16.1	47	19.9	5	8.9	21	13.5	2	3.6	16	14.9
Anthropology	3	5.4	0	0.0	3	5.4	0	0.0	0	0.0	0	0.0
Physics	3	5.4	4	1.7	2	3.6	0	0.0	20	35.7	14	13.1
Anatomy	2	3.6	6	2.5	2	3.6	5	3.2	0	0.0	1	0.9
Earth science	2	3.6	8	3.4	2	3.6	7	4.5	0	0.0	2	1.9
Forestry	2	3.6	0	0.0	2	3.6	0	0.0	0	0.0	0	0.0
Nature Study	2	3.6	32	13.5	1	1.8	25	16.1	0	0.0	29	27.1
Bacteriology	1	1.8	1	0.4	1	1.8	0	0.0	0	0.0	0	0.0
Conservation	1	1.8	0	0.0	1	1.8	0	0.0	0	0.0	0	0.0
Genetics	1	1.8	2	0.8	0	0.0	2	1.3	1	1.8	0	0.0
Heredity	1	1.8	0	0.0	1	1.8	0	0.0	0	0.0	0	0.0
Physical science	1	1.8	3	1.3	1	1.8	0	0.0	0	0.0	1	0.9
Public health	1	1.8	0	0.0	1	1.8	0	0.0	0	0.0	0	0.0
Science for the elementary school	1	1.8	2	0.8	1	1.8	0	0.0	0	0.0	0	0.0
Meteorology	0	0.0	4	1.7	0	0.0	4	2.6	2	3.6	0	0.0
Geography	0	0.0	21	8.9	0	0.0	15	9.7	0	0.0	1	0.9
Physiology	0	0.0	5	2.1	0	0.0	4	2.6	0	0.0	1	0.9

and the median was *14.0*. In School B the mean was *15.36* and the median *15.0*.

Table IV presents certain facts relative to the college science preparation of the elementary student teachers.

Findings

1. In School A more of the students had taken zoology in college than any other science; in School B more had taken biology and health education than any other science.

TABLE V

NUMBERS OF ELEMENTARY STUDENT TEACHERS WHO TOOK COURSES IN SURVEY SCIENCE IN COLLEGE AND THE ATTITUDES THEY EXPRESSED TOWARD THEM

Attendance in and Attitudes Toward Courses in College Science	School A		School B	
	No.	%	No.	%
A. 1. Had taken a survey course	4	7.1	15	16.5
2. Had not taken a survey course	52	92.9	76	83.5
B. 1. Would have taken a survey course if they could have done so	35	62.5	45	49.4
2. Would not have taken if they could have done so	19	33.9	33	36.3
3. No comment	2	3.6	13	14.3
C. 1. Tried to take science courses in college	31	55.3	45	49.4
2. Avoided taking science courses in college	22	39.3	34	37.4
3. No comment	3	5.4	12	13.2

2. In School A more of the elementary student teachers had wanted to take zoology than any other science; in School B more had wanted to take health education than any other science.

3. In School A the subject in science that the elementary student teachers had avoided or tried to avoid most often in college was chemistry, while in School B it was nature study.

Table V deals with the election of survey courses in college science by these elementary teachers.

Table VI presents facts relative to the attitudes of elementary student teachers toward their adequacy of preparation to teach science at the elementary level.

Table VII presents facts relative to the opinions of elementary student teachers with regard to their adequacy of preparation to teach various topics of science at the elementary level.

TABLE VI

OPINIONS OF ELEMENTARY STUDENT TEACHERS TOWARD THEIR SCIENCE PREPARATION

	School A		School B	
Attitude	No.	%	No.	%
Felt adequately prepared to teach elementary science	28	50.0	44	48.4
Did not feel adequately prepared to teach elementary science	28	50.0	47	51.6

Findings

1. In School A more of the elementary student teachers believed themselves more adequately prepared to teach biology at the elementary level than any other science, while in School B, they believed themselves more adequately prepared to teach Nature Study.

2. In both Schools A and B more of the elementary student teachers believed themselves inadequately prepared to teach such

TABLE VII

ATTITUDES OF STUDENT TEACHERS TOWARD THEIR ADEQUACIES OF PREPARATION TO TEACH SCIENCE AT THE ELEMENTARY LEVEL

	Adequate Preparation				Inadequate Preparation			
	School A		School B		School A		School B	
Subject	No.	%	No.	%	No.	%	No.	%
Biology	17	30.4	21	17.5	1	1.7	11	9.8
Botany	15	26.8	2	1.7	4	7.1	2	1.8
Zoology	15	26.8	1	0.8	2	3.5	3	2.7
Geology	10	17.8	0	0.0	8	14.3	7	6.3
Physics	8	14.1	2	1.7	27	48.2	30	26.8
Chemistry	6	10.7	2	1.7	22	39.4	22	19.6
Health education	6	10.7	14	11.7	0	0.0	0	0.0
Astronomy	5	8.9	0	0.0	16	28.6	9	8.0
General science	4	7.1	11	9.2	0	0.0	1	0.9
Nature study	3	5.4	24	20.0	0	0.0	5	4.5
Physiology	3	5.4	2	1.7	0	0.0	0	0.0
Natural science	2	3.5	0	0.0	0	0.0	0	0.0
Physical science	2	3.5	0	0.0	1	1.7	0	0.0
Anatomy	1	1.7	1	0.8	0	1.7	0	0.0
Evolution	1	1.7	0	0.0	0	0.0	0	0.0
Forestry	1	1.7	0	0.0	0	0.0	0	0.0
Physiography	1	1.7	0	0.0	0	0.0	0	0.0
Meteorology	0	0.0	1	0.8	5	8.9	3	2.7
Earth science	0	0.0	1	0.8	1	1.7	3	2.7
Geography	0	0.0	17	14.2	0	0.0	3	2.7
None	0	0.0	12	10.0	0	0.0	1	0.9
No comment	5	8.9	9	7.5	2	3.5	12	10.7

physics as is involved in elementary science than any other science.

Table VIII contains data relative to the amounts of science that the elementary student teachers would expect to introduce into elementary classes.

TABLE VIII

EXTENT OF EMPHASIS OF SCIENCE IN THE ELEMENTARY GRADES

Extent of Emphasis	School A No.	School A %	School B No.	School B %
Great deal	8	14.3	8	8.8
Moderate amount	42	75.0	59	64.8
Very little	5	8.9	8	8.8
No comment	1	1.8	16	17.6

Findings

In both Schools A and B the vast majority of the elementary student teachers indicated their intention to introduce a "moderate amount" of science into their teaching at the elementary level.

2. In both Schools A and B few elementary student teachers indicated their intention to introduce "very little" science into their elementary-school teaching.

MEASURING THE SUBJECT-MATTER COMPETENCE IN SCIENCE OF THE ELEMENTARY STUDENT TEACHERS

The Cooperative General Science Test (Revised Series Form Q) was selected for measuring the subject-matter knowledge of student teachers.

The test was administered according to the directions that accompanied it to the 56 elementary student teachers in School A and 91 elementary student teachers in School B immediately after they had completed the questionnaire.

Six groups of high-school students were then selected at the University of Michigan High School. Two groups consisted of the boys' and girls' homeroom groups at the tenth-grade level; two, of the boys' and girls' homeroom groups at the eleventh-grade level; and two, of the boys' and girls' homeroom groups at the twelfth-grade level. (The members of the two homeroom groups at each grade level are hereafter considered as a single group.) The group at each grade level consisted of the following numbers of students: tenth-grade 46; eleventh-grade 29; and twelfth-grade 54. The test was administered to these pupils at the end of the Spring Semester, during the latter part of May 1951, in accordance with the directions in the test manual.

The "t" test of significance [1] was applied to the differences obtained to determine the significances of the differences between the mean score obtained by the elementary student teachers from each of the schools and the mean score of each group of high-school pupils.

The computations are found in Table IX (see page 404).

Findings

1. The elementary student teachers from School A scored significantly higher than the tenth-grade pupils; the elementary student teachers from School B did not.

2. The elementary student teachers from School A scored very significantly higher than the eleventh-grade pupils; the elementary student teachers from School B did not.

3. The elementary student teachers from School A scored higher than the twelfth-grade pupils but not significantly so; the twelfth-grade pupils scored significantly better than the elementary student teachers from School B.

CONCLUSIONS

In so far as the techniques used in this study may be valid, the following conclusions seem justified.

1. While high-school chemistry was taken more frequently than any other science by the elementary student teachers, it was one that they most frequently had avoided or tried to avoid. High-school biology which was taken by approximately 80 per cent of the students in School A

[1] Guilford, J. P. *Psychometric Methods.* New York: McGraw-Hill Book Co., Inc., 1936. Pp. 61–2.

TABLE IX

COMPUTATIONS FOR SIGNIFICANCE OF DIFFERENCE BETWEEN MEAN SCORES OF VARIOUS GROUPS

	Measures						
Groups Compared	Means *	SD †	Mean Diff.	SE Diff.	"t"	Level of Probability	Interpretation
1. a. Tenth-grade pupils and elementary student teachers (School A)	$M_A = 64.41$ $M_C = 57.85$	$SD_A = 12.42$ $SD_C = 17.41$	6.56	3.20	2.05	$.05 > P > .01$	Significant
b. Tenth-grade pupils and elementary student teachers (School B)	$M_B = 54.28$ $M_C = 57.85$	$SD_B = 14.26$ $SD_C = 17.41$	3.57	3.01	1.19	$P > .05$	Not significant ††
2. a. Eleventh-grade pupils and elementary student teachers (School A)	$M_A = 64.41$ $M_D = 54.04$	$SD_A = 12.42$ $SD_D = 16.23$	10.37	3.64	2.84	$P < .01$	Very significant
b. Eleventh-grade pupils and elementary student teachers (School B)	$M_B = 54.28$ $M_D = 54.04$	$SD_B = 14.26$ $SD_D = 16.23$	.24	3.42	.07	$P > .05$	Not significant
3. a. Twelfth-grade pupils and elementary student teachers (School A)	$M_A = 64.41$ $M_E = 62.94$	$SD_A = 12.42$ $SD_E = 15.36$	1.47	2.87	.51	$P > .05$	Not significant
b. Twelfth-grade pupils and elementary student teachers (School B)	$M_B = 54.28$ $M_E = 62.94$	$SD_B = 14.26$ $SD_E = 15.36$	8.66	2.59	3.34	$P < .01$	Very significant ††

* M_A, M_B, M_C, M_D, and M_E are respectively the means for the elementary student teachers in School A, School B, the tenth-grade, the eleventh-grade and the twelfth-grade pupils.

† SD_A, SD_B, SD_C, SD_D, and SD_E are respectively the standard deviations for the elementary student teachers in School A, the elementary student teachers in School B, the tenth-grade, the eleventh-grade, and the twelfth-grade pupils.

†† These differences are in favor of the students.

and by about 30 per cent of the students in School B was avoided by about 10 per cent in each school. High-school physics was taken by about one half of the students in School A and by about one seventh in School B, but about one fourth of the students had avoided or tried to avoid taking physics in high school. These facts would seem to confirm the results of previous studies that indicate the relatively slight appeal of chemistry and physics for high-school pupils as compared with that of biology. No evidence, however, is here provided to indicate the reasons behind these facts.

2. About 7 per cent of the students in School A and about 16 per cent of the students in School B had taken a survey course in college science, while the rest had not. More than half of the students in School A and about half of the students in School B would have taken such a course if they could have done so. These facts seem to indicate the need both for a survey course in college science that will appeal to such students and for the provisions necessary to make possible their scheduling such a course.

3. Although about 50 per cent of these student teachers considered themselves adequately prepared to teach science in the elementary school, the scores that they obtained on the Coöperative General Science Test do not supply evidence of such competence. It seems likely, therefore, that their conception of both the scope and the depth of subject-matter knowledge required to teach elementary science is a wholly inadequate one.

4. The scores obtained by the elementary student teachers from both schools were not consistently higher than the scores of the students against whom they were compared. This fact evidences the need for a refresher course to aid these prospective teachers in recalling the science that presumedly they have studied at the high-school and college levels. It may also be concluded that teachers preparing to teach elementary science need survey courses in college science to fill some of the gaps in their science subject-matter preparation and to provide a more well-rounded college science program covering the physical as well as the biological sciences.

5. The low scores obtained by these student teachers on a test that is believed to measure subject-matter competence in general science, together with the meagre numbers of courses taken by these students in the various fields of science, indicate both the lack of and the need for a certification requirement that specifies a definite and adequate program for training teachers to teach science in the elementary schools.

RECOMMENDATIONS

1. The present courses of chemistry and physics at both the high-school and college levels should be examined with a view toward the development of more generalized courses of physical science that may offer greater appeal to students.

2. It seems desirable that survey courses in college science be developed for those who are preparing to teach in the elementary school, since many of the participants in this study evidenced a desire for such courses.

3. It is recommended that an extensive study be made to determine the subject-matter preparation in science that is desirable for those who are preparing to teach in the elementary school, since half these student teachers believed themselves inadequately prepared to teach elementary science; particularly topics dealing with the physical sciences.

4. It is recommended also that an effort be made to provide those who are preparing to teach in the elementary school with both an adequate and balanced program in college science, that will appeal to such students, and with the provisions necessary to make possible their scheduling an adequate science program.

THE READING DIFFICULTY OF UNIT-TYPE TEXTBOOKS FOR ELEMENTARY SCIENCE

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INTRODUCTION

During the past twenty years, one of the problems of greatest concern to elementary-school teachers has been that of teaching children to read. There are perhaps a number of reasons for this:

1. The age at which different children are ready to read varies greatly.
2. The skills involved in word preception and phonetic analysis are not completely understood.
3. The optimal procedures for teaching reading have not been definitely established.

The factors just listed, of course, influence greatly the preparation of reading materials for elementary children. Since the age at which children are ready to read varies greatly, it is especially difficult to prepare textbooks for the primary grades suitable for all the children to read. This difficulty carries over also to the intermediate level of the elementary school.

In addition, problems arise in the preparation of instructional materials so that they present optimally the subject matter in the fields for which they are designed, as well as being easy to read.

These problems have been quite apparent in the field of science. A great number of writers and publishers have recognized that textbooks for science that consist chiefly of verbal materials are in many cases unsuitable for primary students, and in some cases for intermediate students. Hence, a number of special techniques have been adopted in the preparation of these textbooks.

1. The levels of reading difficulty of the textbooks are set at a grade level lower than the one at which they are to be used.
2. Science textbooks have been designed for the primary level that contain little or no verbal material but consist chiefly of illustrative material.

Studies[1, 2] have been carried out recently with respect to the reading difficulty of certain of these textbooks of science for the upper levels of the elementary school. In essence, two of these studies indicated that none of the textbooks that were analyzed could be considered as easy reading material for all the students likely to use them. Some of the textbooks were likely to be difficult for any of the students who were likely to use them. In nearly all the textbooks there were some passages that were likely to cause difficulty for even high-school students. It was noted also that textbooks designed for the fourth and fifth grades (the lowest level studied) were likely to be more difficult for the respective students than those designed for the higher levels.

Within the last few years a new type of reference has been prepared for use in

[1] Mallinson, George Greisen, Sturm, Harold E., and Patton, Robert E. "The Reading Difficulty of Textbooks in Elementary Science." *Elementary School Journal,* L (April 1950), 460–3.

[2] Mallinson, George Greisen, Sturm, Harold E., and Mallinson, Lois Marion. "The Reading Difficulty of Textbooks for General Science." *School Review,* LII (February 1952), 94–8.

teaching elementary science, the "unit-type textbook." These materials are usually of pamphlet size and consist of subject matter dealing with individual areas of science, such as television, rocks and heat, instead of covering the breadth of areas usually found in textbooks. It is possible, by using such unit-type textbooks from different publishers, to have instructional materials of different levels of reading difficulty for the same topic. Hence, the differences in reading ability within a classroom may in part be cared for by using the different references.

Nearly all the publishers of these textbooks indicate the grade level or levels at which the materials are likely to be used most effectively. But, a search of the literature fails to reveal any research studies that were undertaken to check the grade placements of the publications, or for that matter, to determine the grade placement of those for which none was given.

THE PROBLEM

Hence, it is the purpose of this study to analyze a sampling of these unit-type textbooks in order to determine their levels of reading difficulty.

METHODS EMPLOYED

The names of all the publishers of the unit-type textbooks were located and the publishers were requested to loan to the investigators a sampling of the publications they believed to be among the best in their listings. The publishers were asked also, if possible, to restrict their selections to publications they deemed usable at the fourth, fifth or sixth grade levels and to provide at least three of them for each level to cover as many areas of science as possible.

It was decided to use the Flesch [3] formula in determining the levels of reading difficulty of the textbooks received. The Flesch formula is based on the assumption that the reading difficulty of material depends on the number of words in the sentences, the relative number of personal references (*I, you,* etc.) in the material, and the number of affixes and suffixes (syllabification) to the words. These various aspects are measured, using a one-hundred-word sample of the material, and are translated into a reading-difficulty score by means of a formula. This reading-difficulty score is converted, in turn, into a grade-level value of reading difficulty.

Since an analysis of all the textual material in all the textbooks was impractical, it was decided to use a modification of the sampling technique suggested by Flesch for use with his formula. Hence, it was decided to select for analysis from each textbook one sample passage for each one hundred pages or fraction thereof, but not less than five passages from any one textbook. In the case of one publisher the material in the textbooks was divided into distinct sections. Hence one sample was taken from each section.

The number of pages in each text was computed by counting from the first page designated by an Arabic numeral to the last page of the last chapter. Pages upon which were found chapter endings, supplementary activities, and questions were included in the count. The pages upon which were found the indices, glossaries, and tables of contents were excluded.

The number of pages thus computed for each textbook was then divided by the number of samples to be taken from the respective textbook. In this way each textbook was divided into sections of an equal number of pages. A page was then selected from each of the sections by using a table of random numbers.[4]

A one-hundred-word sample was taken from each page thus selected by counting

[3] Flesch, Rudolf. *The Art of Plain Talk.* New York: Harper and Brothers, 1946. P. 197.

[4] McNemar, Quinn. *Psychological Statistics.* New York: John Wiley and Sons, 1949. Pp. vii + 364.

from the first word of the first new paragraph on that page. If the page contained no reading material the sample was selected from the next page that did. The legends under the illustrations on the pages thus selected were disregarded. The 191 samples thus obtained were then analyzed using the Flesch formula.

Table I contains the designations given to the various textbooks, together with the reading-difficulty scores for the various samples taken from them:

TABLE I

READING-DIFFICULTY SCORES OF UNIT-TYPE TEXTBOOKS FOR ELEMENTARY SCIENCE

Publisher and Book	Reading-Difficulty Score of Samples						Average Reading-Difficulty Score
	1	2	3	4	5	6	
Publisher 1							
Book A	1.31	1.11	1.37	1.11	1.69	....	1.32
" B	1.36	.76	1.19	1.50	1.87	....	1.34
" C	1.22	2.02	1.81	1.55	1.55	....	1.63
" D	2.25	1.95	1.89	2.60	2.01	....	2.14
" E	2.42	2.28	1.75	2.23	1.57	....	2.05
" F	2.36	1.97	1.57	1.30	1.12	....	1.66
" G	1.17	1.16	1.15	2.08	1.69	....	1.45
" H	.64	3.32	2.08	1.82	2.02	....	1.98
" I	1.56	1.61	1.69	2.09	1.42	....	1.67
Publisher 2							
Book A	2.54	1.90	1.24	1.50	1.42	....	1.72
" B	1.16	1.55	1.75	1.70	1.49	....	1.53
" C	1.11	1.24	1.29	1.36	1.08	....	1.22
" D	2.14	1.98	1.23	1.30	.91	....	1.50
" E	2.15	1.57	2.83	1.29	2.02	....	1.97
" F	1.57	1.29	1.82	1.94	1.16	....	1.56
" G	1.29	1.76	1.36	1.27	1.61	....	1.46
" H	1.43	1.11	.61	1.31	1.41	....	1.17
" I	2.28	1.56	1.03	1.11	1.30	....	1.46
" J	1.56	1.24	2.15	1.62	1.17	....	1.55
" K	2.09	1.71	1.11	2.16	.05	....	1.42
" L	1.51	1.04	1.43	1.81	1.69	....	1.50
Publisher 3							
Book A	2.36	1.96	1.89	2.54	2.03	....	2.16
" B	1.63	1.97	1.37	2.55	1.28	....	1.76
" C	1.43	2.64	1.97	2.64	2.56	....	2.25
" D	1.68	1.68	1.42	1.29	1.89	....	1.59
Publisher 4*							
Book A	1.42	1.75	1.23	1.80	1.22	1.76	
	1.23	.65	2.22	2.67	1.89	1.03	1.57
" B	1.69	1.75	1.69	1.16	1.63	1.23	
	1.63	1.69	1.43	2.28	2.22	1.89	1.69
" C	1.16	.83	1.55	1.22	1.48	2.19	
	1.04	1.70	1.10	1.68	1.03	.44	1.29
Publisher 5							
Book A	1.49	1.49	2.96	.97	2.02	....	1.79
" B	2.76	2.87	3.45	2.80	2.21	....	2.82
" C	3.05	2.99	3.65	2.73	2.52	....	2.99
" D	4.46	2.44	3.33	1.82	1.69	....	2.75
" E	2.16	2.57	1.76	2.83	2.69	....	2.40
" F	2.70	1.89	2.23	2.29	1.17	....	2.06

* Twelve samples were taken from each of the textbooks of Publisher 4. For convenience of tabulation the samples have been listed as two groups of six each.

TABLE II

GRADE LEVELS OF DIFFICULTY EQUIVALENT TO READING-DIFFICULTY SCORES *

Reading-Difficulty Scores	Description of Style	Grade Level of Difficulty
0–1	Very easy	4th grade COMPLETED
1–2	Easy	5th grade COMPLETED
2–3	Fairly easy	6th grade COMPLETED
3–4	Standard	7th or 8th grade level
4–5	Fairly difficult	2 years of high school
5–6	Difficult	High school and some college
6 and up	Very difficult	College COMPLETED

* Flesch, Rudolf, op. cit., p. 205.

TABLE III

COMPARISONS OF PUBLISHERS' GRADE-LEVEL INDICATIONS WITH THOSE FROM THIS STUDY

Publisher and Book	Publishers' Grade Level of Difficulty	Computed Grade Level of Difficulty
Publisher 1		
Book A	4th	5th grade
" B	4th	5th grade
" C	4th	5th grade COMPLETED
" D	5th	6th grade
" E	5th	6th grade
" F	5th	5th grade COMPLETED
" G	6th	5th grade COMPLETED
" H	6th	5th grade COMPLETED
" I	6th	5th grade COMPLETED
Publisher 2		
Book A	Intermediate	5th grade COMPLETED
" B	Intermediate	5th grade COMPLETED
" C	Intermediate	5th grade
" D	Intermediate	5th grade
" E	Intermediate	5th grade COMPLETED
" F	Intermediate	5th grade COMPLETED
" G	Intermediate	5th grade
" H	Intermediate	5th grade
" I	Intermediate	5th grade
" J	Intermediate	5th grade COMPLETED
" K	Intermediate	5th grade
" L	Intermediate	5th grade
Publisher 3		
Book A	No indication	6th grade
" B	No indication	5th grade COMPLETED
" C	No indication	6th grade
" D	No indication	5th grade COMPLETED
Publisher 4		
Book A	4th	5th grade COMPLETED
" B	5th	5th grade COMPLETED
" C	6th	5th grade
Publisher 5		
Book A	4th	4th grade COMPLETED
" B	4th	6th grade COMPLETED
" C	4th	6th grade COMPLETED
" D	4th	6th grade COMPLETED
" E	4th	6th grade
" F	4th	6th grade

The conversion of reading-difficulty scores into grade levels of difficulty is made by using the data in Table II.

Table III contains the designations given to the various books analyzed, the grade-levels of reading difficulty indicated by the publisher, and the grade-levels of difficulty as they were computed in this study.

CONCLUSIONS

In so far as the techniques employed in this study may be valid, the following conclusions seem justified:

1. A study already cited [5] indicated that textbooks in elementary science were in a number of cases likely to cause difficulty for the students for whom they are designed. The present study fails to offer much encouragement to teachers who use the unit-type textbooks, at least in so far as using them at the grade level indicated by the publisher.

2. The unit-type textbooks of Publisher 1 are likely to cause difficulty for students of elementary science, especially those designed for the fourth-and fifth-grade levels. Those for the fourth-grade level were found to be of fifth-grade level of reading difficulty. Two of those for the fifth-grade level were found to be of sixth-grade level of reading difficulty. In general, it may be stated that any of the textbooks of Publisher 1 are likely to be difficult for some, and in many cases most, of the students to read.

3. The unit-type textbooks of Publisher 2 are all listed as being of "intermediate level" of reading difficulty. If intermediate level is considered to be the fourth through the sixth grades, all the textbooks fall "in the middle" of this level with respect to reading difficulty. They are likely to be difficult for all but a few fourth graders, difficult for some fifth graders, but probably suitable for most sixth graders. It would seem therefore that they are most usable at the upper grades of the intermediate level.

[5] Mallison, Sturm and Patton, op. cit.

4. The unit-type textbooks of Publisher 3 were not graded but are "suggested" for use at the intermediate level. However, it would seem that they are most suitable for students of at least average reading ability at the sixth-grade level or even higher.

5. The unit-type textbook of Publisher 4 designed for the fourth grade is likely to be quite difficult for fourth graders; the one for the fifth grade, likely to be difficult for all but the better fifth graders; while the one for the sixth grade is likely to be satisfactory for nearly all the sixth graders.

6. The unit-type textbooks of Publisher 5, all of which are listed as suitable for fourth graders, were found, with one exception, to be well above the level of the students for whom they were designed. It is unlikely that any of them would be suitable for students below the junior-high-school level.

7. It may be noted that *average* levels of reading difficulty in the cases of some of the unit-type textbooks are meaningless. Some passages may be well below the levels of reading ability of students in the grades for which they are designed, while other passages are well above.

SUMMARY

It may be stated that if teachers have found textbooks of elementary science generally too difficult, they are not likely to find the unit-type textbooks much better if they use them at the grade levels that the publishers suggest. However, it is recognized that these textbooks may be used suitably, in so far as reading difficulty is concerned, at higher grade levels. Further it is probably easier to shift these pamphlet-type materials to suit reading abilities than to shift textbooks. However, there is less likely to be integration among the areas dealt within the unit-type textbooks, than among the areas found in conventional textbooks.

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